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WORLD PETROLEUM

NEW YORK AND LONDON

JULY 1939

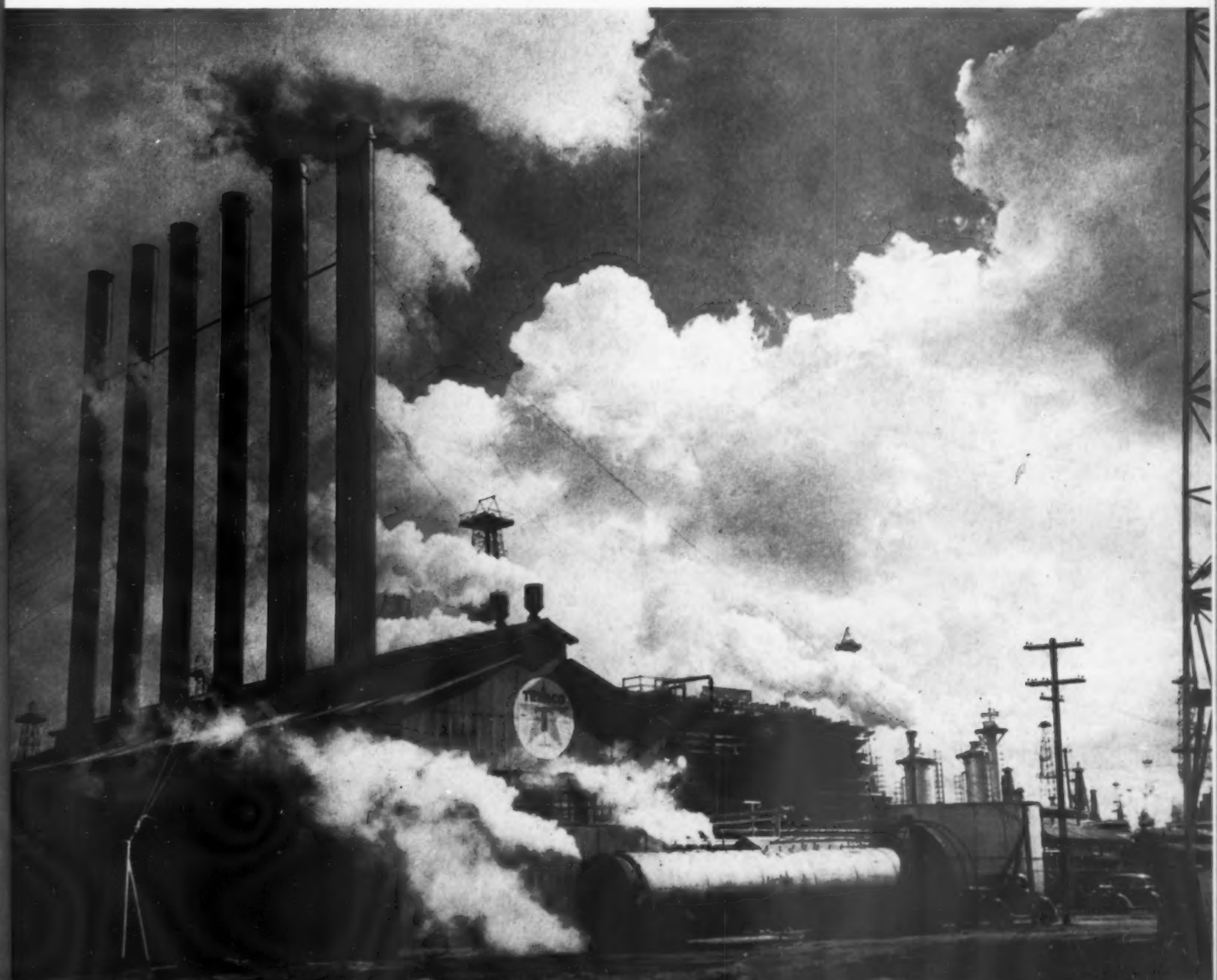
NEW YORK WORLD'S FAIR

AVIATION'S STRIDES EXPAND DEMAND FOR 100 OCTANE FUEL

OIL DECREES CREATE FINANCIAL BURDENS FOR FRENCH INDUSTRY

VOLUNTARY CURTAILMENT IN CALIFORNIA

Photo by Cy La Tour & Son



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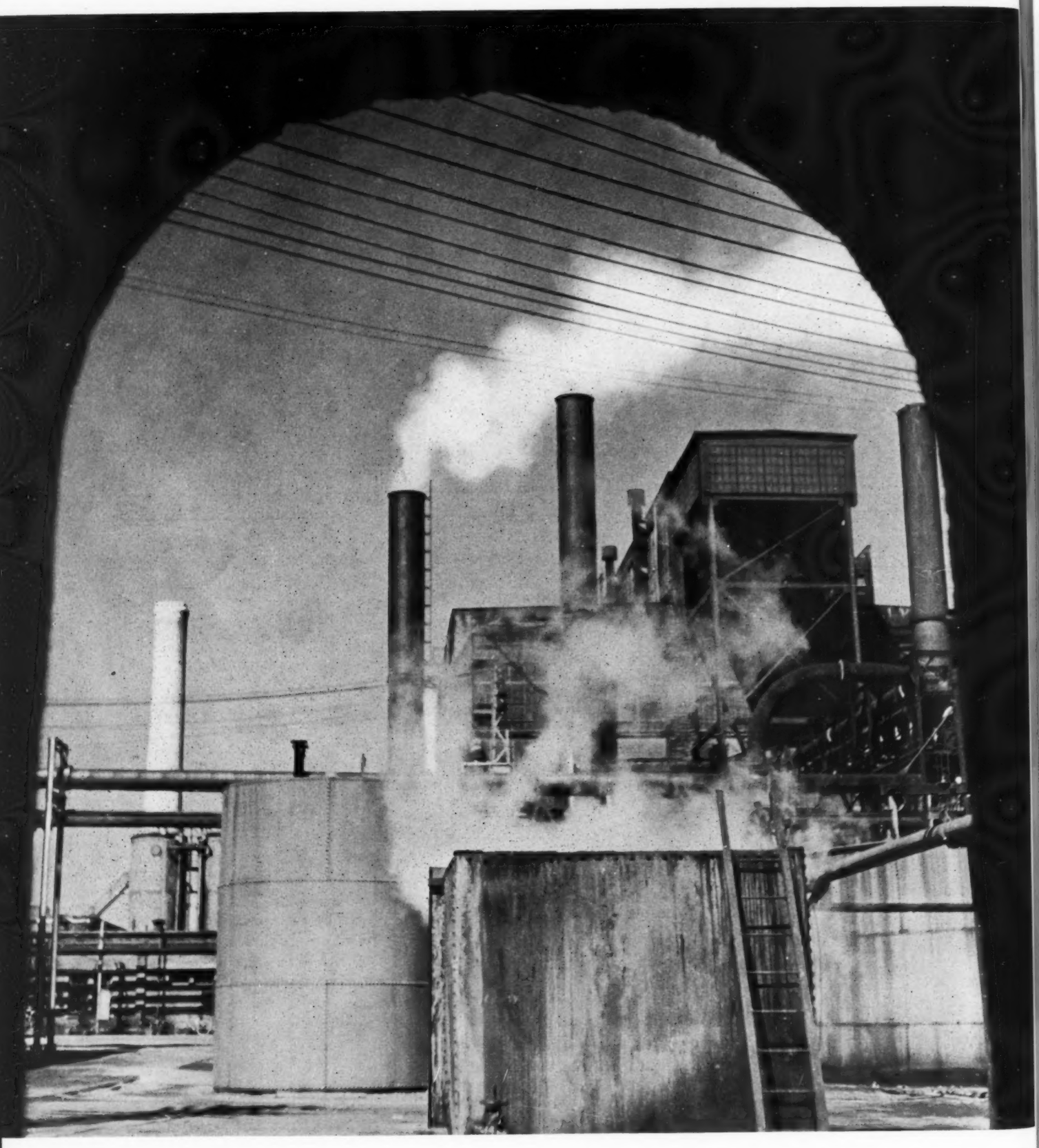


Central Boiler House at Jersey Standard's Bayway Refinery.

EDITORIAL

VOLUNTARY PRORATION IN CALIFORNIA

CALIFORNIA is an oil empire in its own right. Its daily output exceeds that of any country except the United States. It presents a great diversity of producing conditions with wells ranging in capacity from a few barrels to more than 20,000 bbls. daily. Ownership is divided among hundreds of individuals and corporations. Among these are included a few financially strong and fully integrated companies and a vastly greater number whose primary concern is the maintenance of a modest income or the rapid recovery of sufficient oil to repay obligations incurred in development.

A more difficult test for any system of regulation, or a seemingly more unpromising field for the establishment of a successful program of voluntary proration, than presented by such widely divergent types of ownership could hardly be imagined. Yet for nearly ten years past consistent effort to carry on such a program has been maintained. The movement has experienced varying fortunes. In periods of expanding demand it has operated smoothly and effectively. At other times, when markets turned stagnant or new flush fields were brought in, it has been perilously close to failure and some of its most zealous adherents have been ready to abandon the struggle. Throughout the greater part of the period since 1929, however, it has succeeded in keeping a reasonable balance between supply and demand in California, thereby conserving the interests of producers, royalty owners and the public.

During this decade, many new fields have been brought into production within the state and its potential output has risen, not steadily but at intermittent periods as new discoveries have occurred. As a consequence, practically every problem connected with the prevention of waste and avoidance of market demoralization has been encountered. Out of this experience has been evolved a constantly improving system of regulation which has come to be recognized as equitable both to small and large producers. In view of this fact and of the importance of the subject to the oil industry at large, WORLD PETROLEUM is pleased to be able to present on other pages of this issue the story of voluntary proration in California told by the man who is qualified above all others to write it because for the greater part of its history he has been a vital part of its operation and development.

State Law Enacted

IT IS interesting to note that as time has gone on practically all those concerned with the oil industry in California have become convinced of the necessity of maintaining some equitable form of proration. While the large integrated companies were the first to practice and to urge curtailment, the smaller producers, the independents, are the ones who have taken steps to revive the regulatory program when it has seemed about to break down and when the major companies have been on the point of abandoning it.

As a result of the example set by the industry during the past decade and of the resultant growth of sentiment in favor of oil conservation it appears that State regulation is about to replace voluntary proration. A bill providing for a state commission to fix allowables and prorate production was passed by the state legislature late in June as one of its last acts before adjournment. Backed by the authority of the state, the enforcement of authorized measures of conservation can be made more complete and certain than through a system that depends upon the co-operation of thousands of individual units. Even though the field committees, the central committee and the oil umpire can now turn over their tasks to an officially-established commission, they still deserve full credit for having upheld the voluntary system through nearly ten years, during which time they have saved millions of dollars for the citizens of the state by checking the waste of its petroleum resources and preventing demoralization of one of its most important industries.

New York WORLD'S FAIR

Petroleum Plays Prominent Part Among Industrial Exhibits and International Pavilions—Oil Industry's Building Acclaimed as One of the Most Educational at the Fair.

OIL takes an important place at the New York World's Fair of 1939, being featured not only at the industry's own exhibit but also in the international section at the Venezuelan Iraqi and Brazilian pavilions. The Petroleum Industries Exhibit, especially, vividly portrays the contribution of the oil business to civilization and suggests the important part to be played by petroleum in the world of tomorrow.

The exhibit was dedicated on April 25th and the World's Fair itself was declared open formally by President Roosevelt on April 30th. By the end of June, some 11,900,000 visitors from all parts of the world had entered its gates. Visitors, exhibitors and Fair officials alike have been lavish in their praise of the Petroleum Industries Exhibit and acknowledge it to be one of the outstanding industrial shows on the grounds.

The petroleum exhibit is distinctive even in the company of the other striking buildings that make the Fair so grand a show. This distinctiveness lies in the fact that the building combines beauty of structure with functional beauty, being designed in an idealized form of a refinery cooling tower. The structure is an equilateral triangle with 200 ft. sides and standing 80 ft. high. Alongside the building is a 199 ft. derrick demonstrating actual drilling operations for the enlightenment of the visitors. The building is raised 20 ft. off the ground, resting on huge

The 199 ft. oil derrick at the Petroleum Industries Exhibit is one of the tallest structures at the New York World's Fair and is pictured here against the Trylon and Perisphere, theme center of the fairgrounds.

W. P. Staff Photo

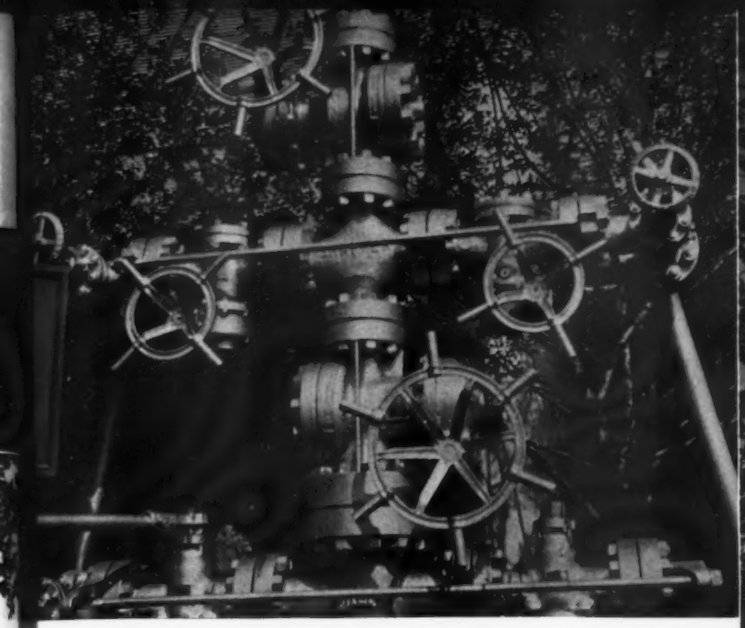
The Petroleum Building is designed as an idealized form of cooling tower, triangular in shape, supported by four storage tanks. Painted in several pastel shades of blue, it is strikingly beautiful at night with its cleverly-placed indirect illumination.

On the roof of the Petroleum Building there is a pleasantly designed garden with adequate facilities for quiet refreshment.

cylindrical steel forms designed to represent oil storage tanks.

The building alone covers 28,166 sq. ft. and to support a structure of this size on the soft ground of Flushing Meadows, where the New York World's Fair has been constructed, it was necessary to sink 338 fir piles to their full 100 ft. length and to cap them with concrete. The cost of the building itself ran to $265,000.

At night, the Petroleum Building is particularly attractive, for clever lighting effects have been achieved by the use of indirect lights of a deep blue color, coming from behind the planes that conceal the source of



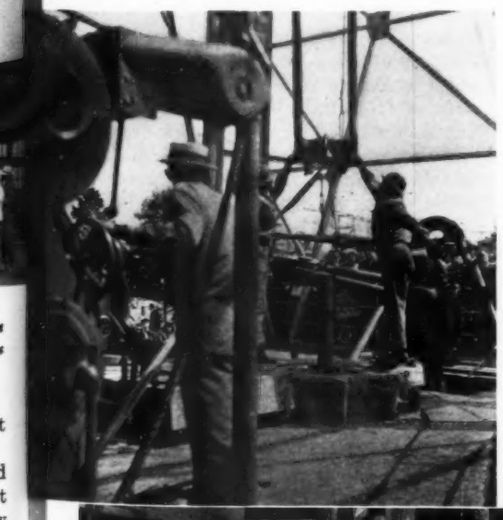
W. P. Staff Photos

Oilfield pumps, Christmas trees, lease tanks, and separators are placed in the midst of little groves all around the main building of the Petroleum Industries Exhibit, each being identified by a large sign which explains to the general public their individual uses in the oil business.

light. In addition, floodlights on the derrick make it possible for the oil exhibit to vie for top honors with the other splendid lighting effects that illuminate the entire fair grounds.

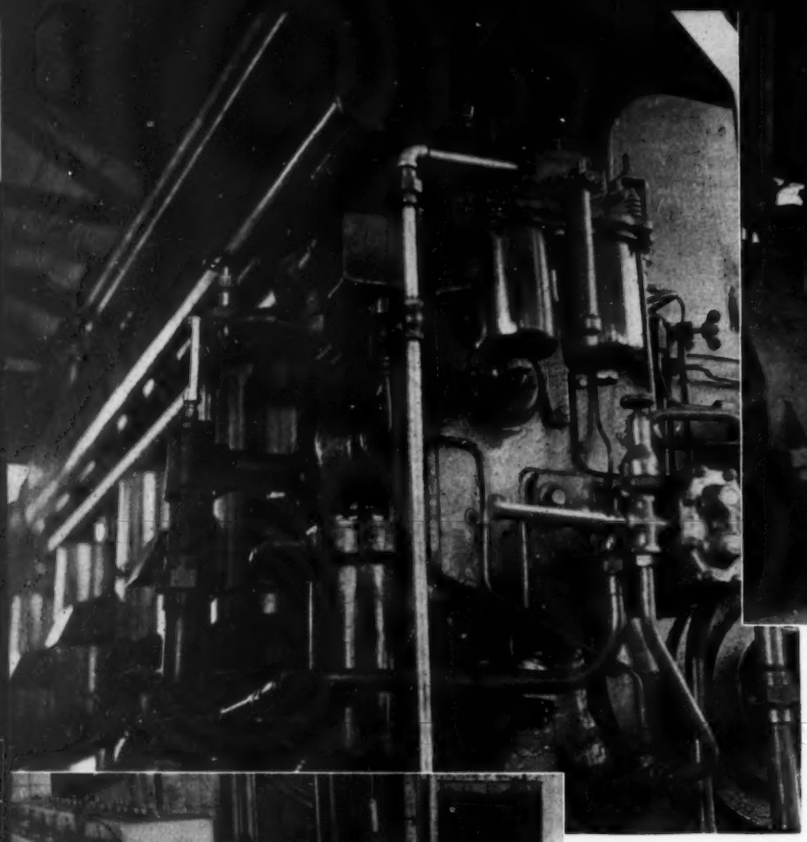
The building is designed so that visitors may enter on all three sides. Once within the building, the visitor finds himself confronted by a variety of interesting and elaborate displays. Perhaps the most striking of these is the animated map, a full relief display surrounded by water. This map measures 50 ft. across. Small derricks mark the location of the oilfields; neon tubes show the routes followed by pipelines; tiny engines pull trains of miniature tank cars up mountains, across rivers and plains, showing the distribution of oil to consuming centers; model tankers move on the water routes from fields to refineries.

Technicolor movies, with a cast of animated rubber puppets starring Pete Roleum, are shown every hour. The picture depicts the story of oil in America, the place it fills in the world of today, the part it will play in the world of tomorrow, and a conception of the world as it would be if petroleum products no longer were produced. This picture, accompanied by a specially written musical score, is shown on one of the largest screens in the world.



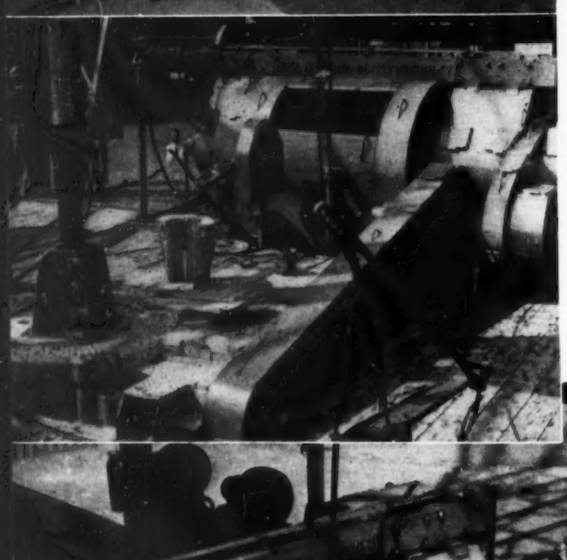
While walking through the fairgrounds the public is first attracted to the Petroleum Industries Exhibit by the huge drilling rig with a Mid-Continent crew putting the equipment through its paces. Bottomed in granite at about 400 ft., the well is ostensibly drilling ahead. Below, from left to right—M. L. Bills, Garber, Okla.; Roy Franklyn, Oklahoma City; chief driller Charles Brown, Stillwater, Okla.; and Leonard Thompson, Guthrie, Okla.

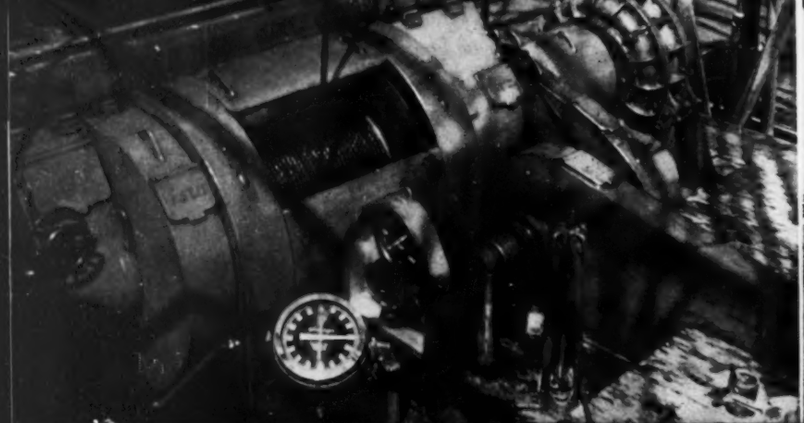
Four vast murals decorate the walls of the Great Hall of the Petroleum Building—each as high as a four story house. They were executed by William Tefft Schwarz and depict various phases of the petroleum industry. One show the oilfields with drilling rigs in operation and the crew working against a background of some of the developments made possible by petroleum. Another shows oil shipped by tankers and pipelines to refineries. In the third mural, men are portrayed working in a modern refinery while the fourth shows research scientists at work on their experiments that have played so important a part in the development of the modern world.

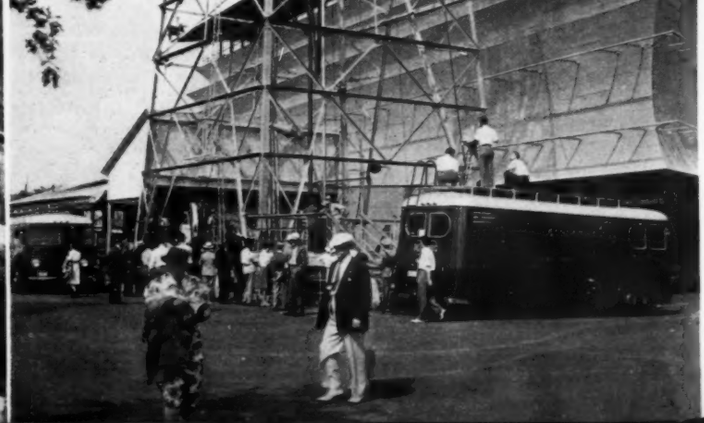


W. P. Staff Photos

Some of the latest developments in rotary tables, draw-works, and instruments are to be seen at the drilling rig at the exhibit of collaborating oil companies at the New York World's Fair. The picture at the bottom, right, shows the National Broadcasting Company's trucks at the well-site during a 50 min. television broadcast over Station W2XBS—undoubtedly the first time such a program has been televised. Some 800 sets within a radius of 55 mi. of central New York City received views of the drilling activities.







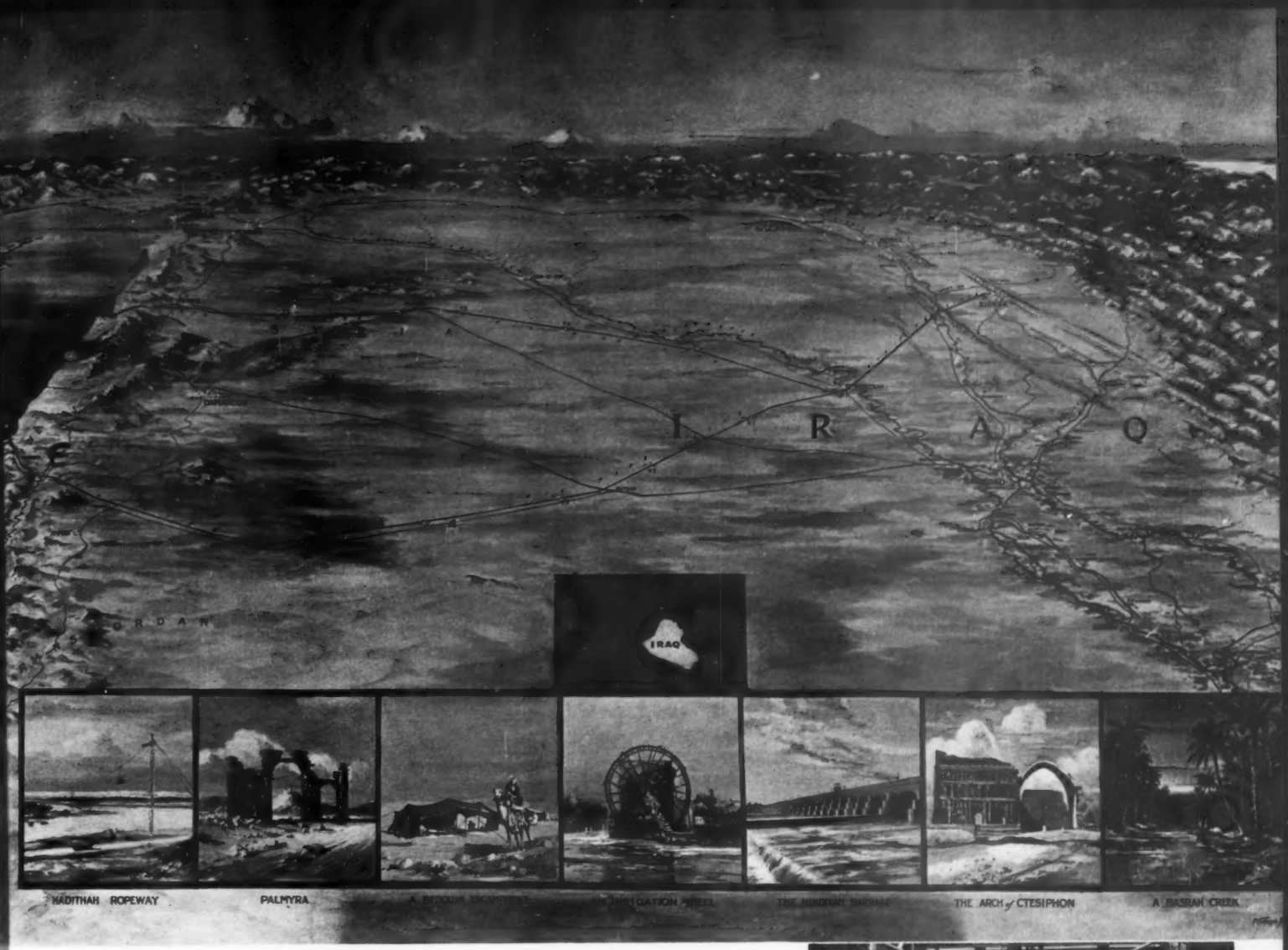
Also to be found in the Great Hall is the glass model of a refinery. This model operates in such a manner that the observer can see the process simulated by colored liquids at the same time as he hears the explanatory voice.

The four cylindrical supports of the building serve in an additional capacity as small exhibit halls, each of which is devoted to petroleum's contributions to some phase of modern life. The first of these tanks shows the many ways that oil adds to the comforts of the home. The second displays the part of petroleum in the industries of today. The third tank, the one devoted to the contributions of petroleum to transportation, shows an ox-cart creaking on rusty wheels, against a background of super airplanes, stream-lined trains and swift ocean liners. The last tank shows, graphically, what happens to every dollar spent for gasoline and other petroleum products.

On the top of the Petroleum Building is a roof-garden club for oil men. With restaurant facilities, tables, awnings and shrubbery, and providing an excellent vantage point from which to view the entire Fair, this spot is a cool retreat and provides a convenient meeting place for oil men, who can afford the somewhat exclusive prices.

Alongside the building stands a huge derrick which, with its drilling crew, continually demonstrates drilling operations to the crowds at the Fair. Before the interested spectators, the drilling crew ride up and down the derrick on the huge block, lower lengths of pipe down into the Flushing Meadow, join the heavy lengths together and proceed with the actual drilling. One of the drillers periodically described the operations to the public on the viewing stand. The magnitude of the job and the sang-froid of the crew seem to attract a large percentage of the Fair visitors, who find this particular part of the Petroleum Exhibit one of the most interesting features of the entire Fair.

The oil exhibit is operated by a special corporation formed by a number of leading American oil companies. Incorporated under the name, Petroleum Industries Exhibition, Inc., the company is headed by Thomas H.



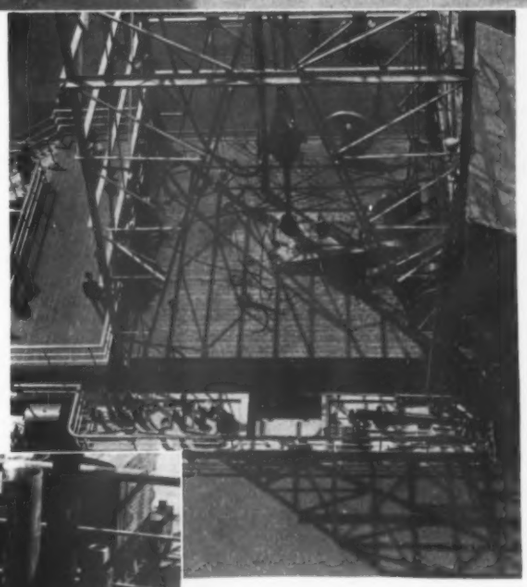
Courtesy Iraq Petroleum Co. Ltd.

Large murals were made for the Iraq National Exhibit at the New York World's Fair illustrating the petroleum developments in that part of the Middle East. Above is the map showing the route of the Kirkuk-Mediterranean pipeline while other pictures show oilfield scenes, aerial views of the Kirkuk structure, and a geological cross-section of the field.

Taylor. During 1937, the oil companies abandoned plans for individual exhibits and decided to combine their efforts. The concerns that organized the corporation with this in mind include Shell Oil Corporation, Standard Oil Company of New Jersey, Socony-Vacuum Oil Company, Inc., The Texas Corporation, Gulf Oil Corporation, Sun Oil Company, Sinclair Refining Company, Pure Oil Company, Atlantic Refining Company, Tide Water Associated Oil Company, Cities Service Oil Company, Phillips Petroleum Company, Richfield Oil Corporation of New York, American Oil Company and Ethyl Gasoline Corporation. No oil company trade marks or brand names are displayed and the exhibit benefits the entire oil business.

Petroleum Industries Exhibition, Inc., was formed for the purpose of creating public understanding of the essential services rendered by the oil business. The company is only part of the industry's broad public relations program. It is designed to show not only the uses of petroleum but also to show the recognition, by the industry, of its social responsibility—a recognition that manifests itself in the industry's attempts to conserve the natural resources of the world, in its high wage scale and in its employee provident funds.

While the average visitor to the Petroleum Exhibit will find his interest centered upon the fact that petroleum is vital to the manu-

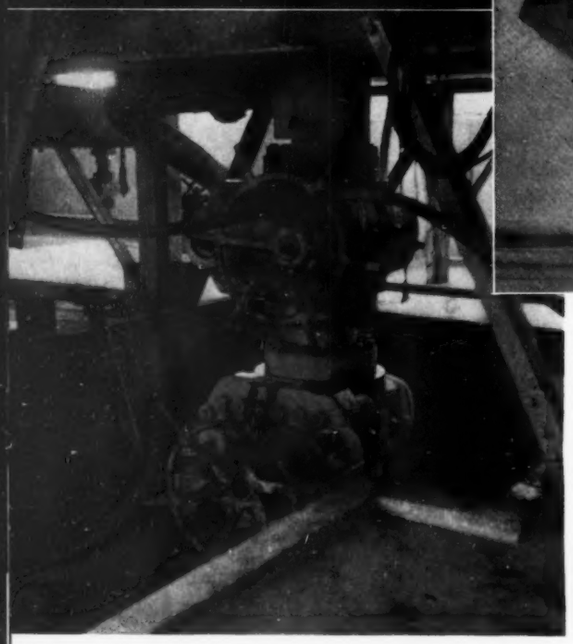


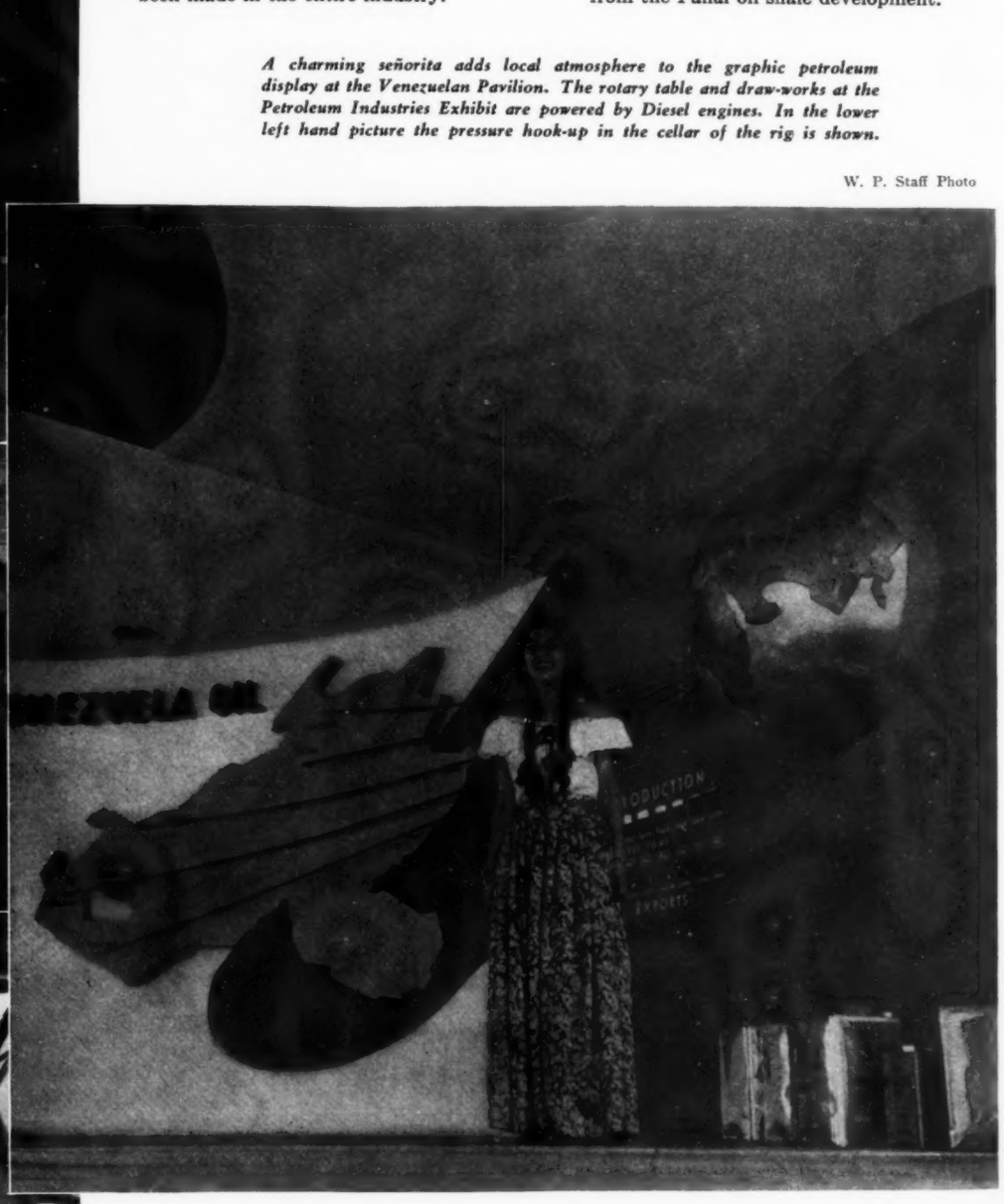
Right—A raised platform has been erected beside the derrick floor so that the public may watch the drilling operations. Below—Stands nearby display reamers, core barrels, and other smaller equipment.

W. P. Staff Photo

facture of products used daily such as chewing gum, matches, paint, cosmetics, wax paper, insecticides and automobile tires, members of the industry also will find much to hold their attention. At the exhibit is presented a compact and striking record of the recent, important advances that have been made in the entire industry.

In the Venezuelan Pavilion there is an interesting display showing the importance of petroleum among the nation's exports while the Iraqi exhibit has murals depicting the I. P. C. pipeline and the structure of the Kirkuk field. The Brazilian Government is exhibiting samples of the products obtained from the Panal oil shale development.





A charming señorita adds local atmosphere to the graphic petroleum display at the Venezuelan Pavilion. The rotary table and draw-works at the Petroleum Industries Exhibit are powered by Diesel engines. In the lower left hand picture the pressure hook-up in the cellar of the rig is shown.

W. P. Staff Photo

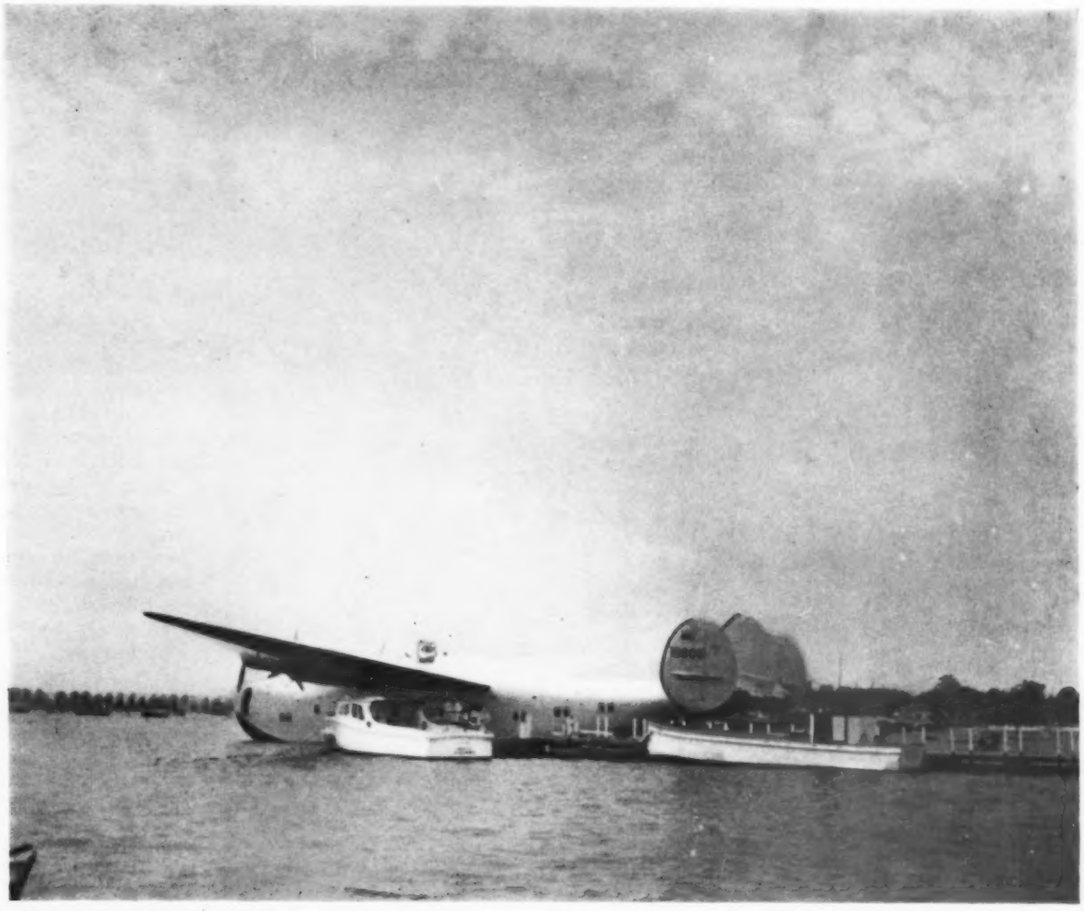
PHILIPPINES TO BE DRILLED BY GOVERNMENT

ALL prospective oil lands in the Philippines, with the exception of a few leases in the hands of private firms, have been reserved for exploration by the National Development Company, a Philippine government owned corporation. To undertake this extensive survey which has recently commenced, a group of oil geologists and paleontologist—Robert M. Kleinpell, Joseph Hollister, W. P. Popenoe, and C. N. Nelson—have been engaged under the direct supervision of Grant W. Corby and H. N. Johnson. Mr. Corby is also under contract with the Far East Oil Development Company, a local oil concern now engaged in drilling a shallow test on the Bondoc Peninsula in the province of Tayabas.

It has been announced that all government efforts will be concentrated on exploration work for at least a year before areas are selected for drilling. An expenditure of approximately $125,000, has been appropriated for this purpose.

Aviation's New Strides Expand Demand for 100 OCTANE FUEL

By A. F. Maple



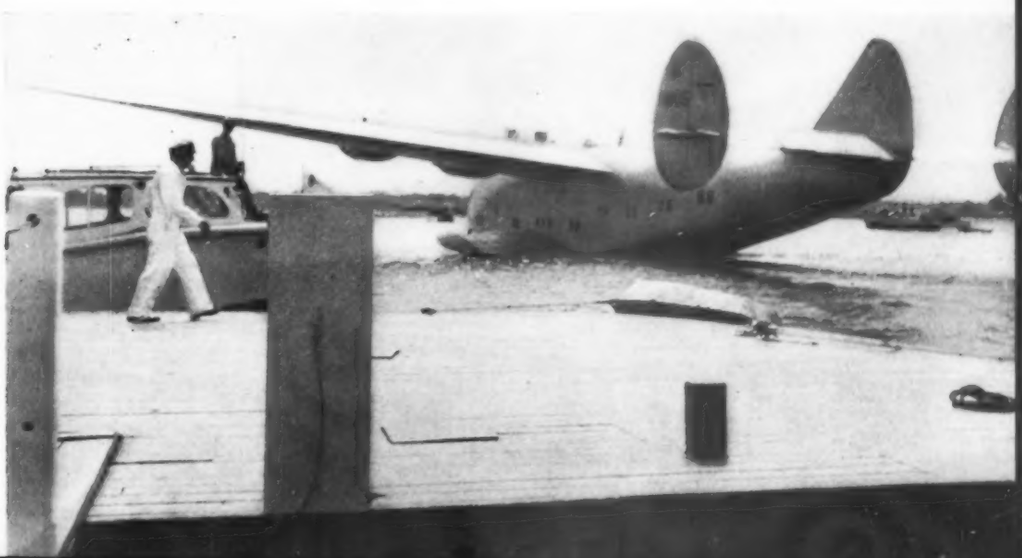
The inauguration of trans-Atlantic air service over the northern route by the Dixie Clipper has opened up a new market for 100 octane aviation gasoline. This flying boat and her sister ships on the same run are equipped with tanks capable of loading 4,200 gal. at a time. 300 gal. of lube oil may also be carried.

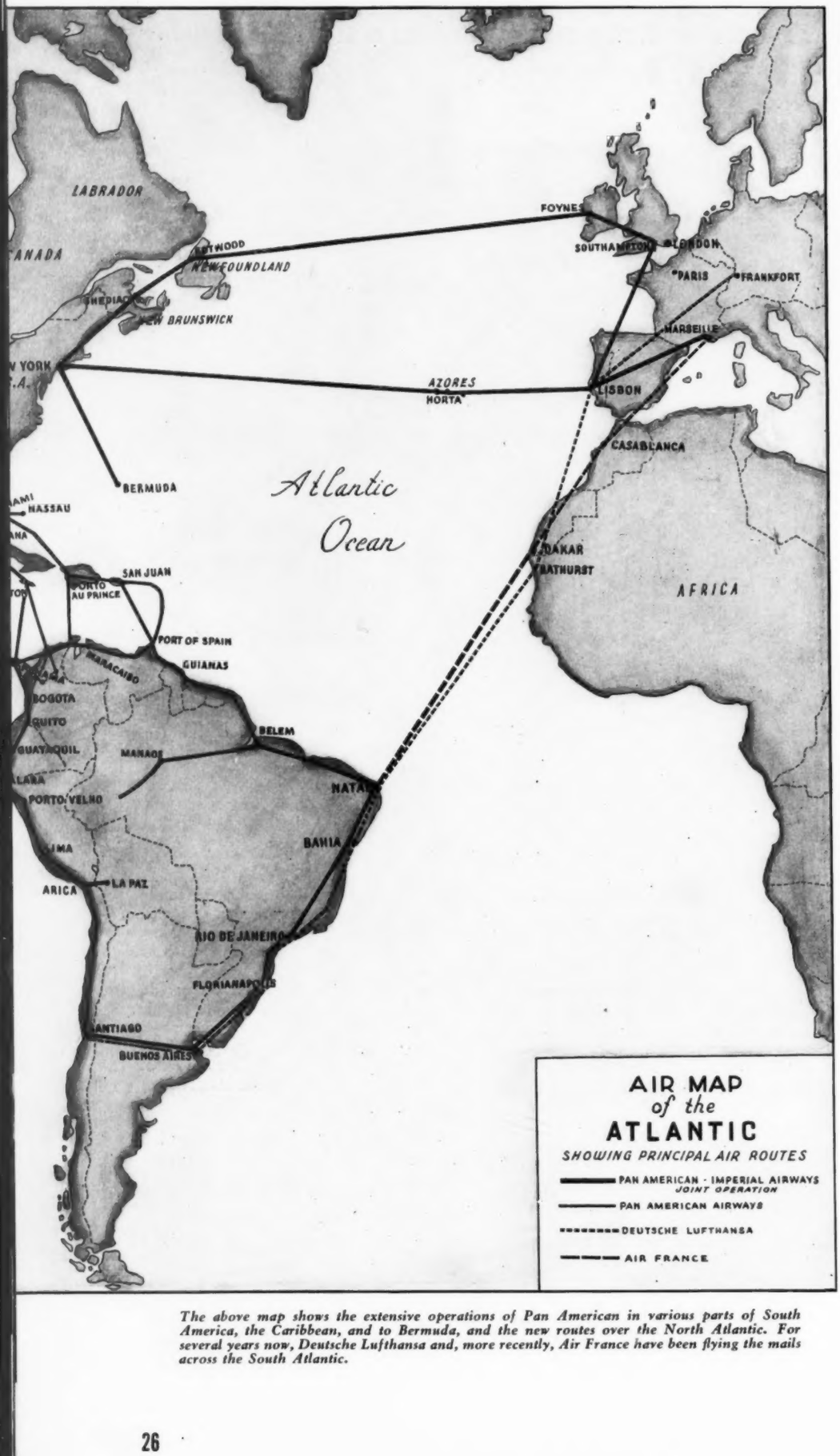
Captain T. Rieber, chairman of The Texas Corporation, helps to make aviation history as he gets his ticket at Pan American Airlines' office at Port Washington just before the flight. His was the second booking made for this flight, and like the other passengers, he received a silver cigarette case on which was engraved a facsimile of his ticket. The picture to the bottom right shows the Dixie Clipper leaving on the first stage of the initial passenger-carrying flight to Europe.

W. P. Staff Photos

IN THE afternoon of June 28th, a bell sounded at Port Washington, L. I. Twelve men in uniform marched briskly out of a hangar, crossed a 300 ft. walk-way to a float and boarded a 40 ton flying boat. A few minutes later two bells sounded, and a group of some 22 men and women stepped aboard. Soon hatches were sealed, four 1,500 hp. engines were accelerated slightly and the 52 passenger Dixie Clipper moved majestically across the surface of Manhasset Bay. In less than a minute the big ship was in the air, her nose pointed eastward on a scheduled flight to Eurpoe—the first airplane to cross the North Atlantic in regular passenger service.

Even the most indifferent observer could not fail to recognize the significance of this event. Scarcely a dozen years have passed since the world acclaimed the non-stop flight of a lone young man from New York to Paris. Yet today engines of the same essential design





The above map shows the extensive operations of Pan American in various parts of South America, the Caribbean, and to Bermuda, and the new routes over the North Atlantic. For several years now, Deutsche Lufthansa and, more recently, Air France have been flying the mails across the South Atlantic.

have been so improved in power and reliability that four of them can lift 52 persons and their luggage, and carry them to Europe, not only at a much greater speed than Lindbergh, but also with all the casualness and comfort of an ocean-going liner.

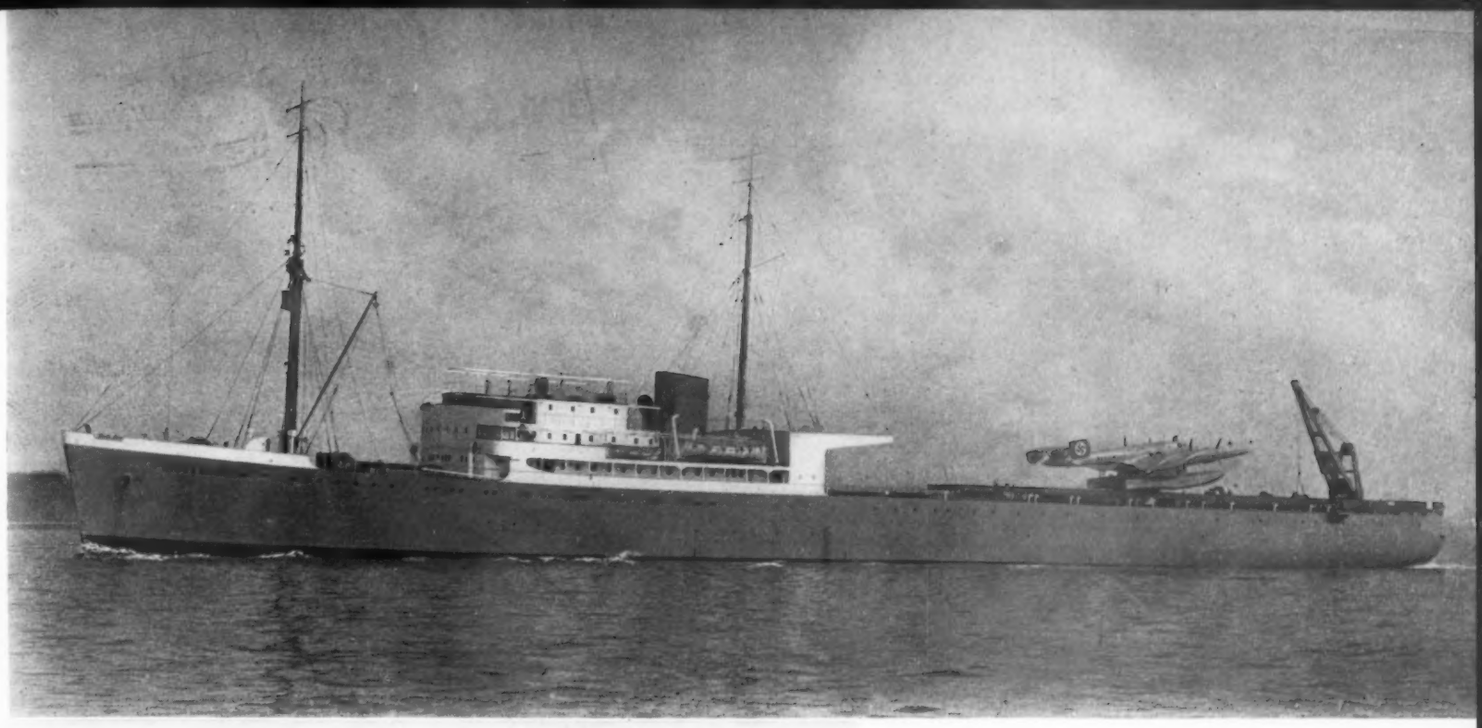
In a sense, the inauguration of trans-Atlantic passenger flying marks the coming-of-age of aviation. Yet, although Pan American Airways is receiving (and assuredly deserves) the loudest public acclaim for its triumph of organization and engineering, the other classes of aviation of which far less is heard also are rapidly approaching maturity. Whereas trans-Atlantic air transport has definitely arrived, these others may be truly said to be just around the corner.

In 1935, in these pages, it was pointed out that the aviation industry was showing a marked tendency to divide itself into three distinct classes, each going more and more its own way. Of the three, air transport was the most important economically, and had made the greatest progress in refinement and efficiency of equipment. That is still true, as the success of Pan American Airways' Pacific and Atlantic ventures bears witness.

Even more convincing testimony—if any be needed—may be found in government statistics which show that, although there were over 100 fewer aircraft operating in scheduled services in 1938 than in 1935, they carried nearly twice as many passengers and flew nearly 18,000,000 more miles. That record can be attributed to only one thing—increased operating efficiency through steady improvement of aircraft and engines, making it possible to carry larger and larger loads at greater and greater speeds. That improved efficiency, in turn, must be credited largely to the trail-blazing done by the oil companies in developing better grades of fuels and lubricants which have greatly increased the aircraft engine's power output without an equivalent increase in weight. In a true sense the airlines have spent the last four years in settling and cultivating the land which the oil companies had already explored.

As the aftermath of Munich, the second category of aviation—military flying—has received far more stimulus than anyone could have predicted in 1935. A few years ago, the United States Army Air Corps was regarded in official circles as just another branch of the service; today it seems suddenly to have become the most important arm of national defense. The result is that government money is being poured into it in unprecedented amounts (the new Air Corps appropriation will probably run to $292,000,000), and military aircraft are being turned out in greater numbers than at any time since the World War.

With this sudden shift, the oil companies find themselves confronted with new problems. In supplying the air services, they inevitably will be called upon to produce army-specification gasoline (mostly 100 octane) and oil in much greater quantities than heretofore. By virtue of a recently developed process for producing 100 octane gasoline, which is discussed more fully later



Photos courtesy World Tankship Publications

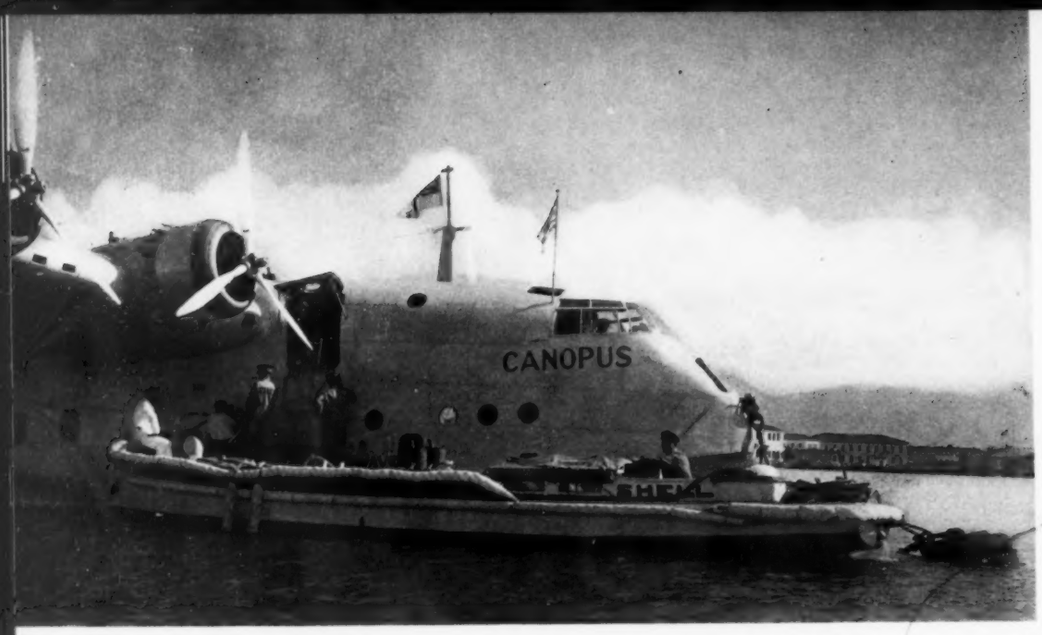
Deutsche Lufthansa has been carrying airmail across the South Atlantic, but using Diesel-powered seaplanes. The specially-designed base-ship Friesenland, shown above, was stationed in Long Island Sound, New York, for a considerable time while survey flights were being made for the company's proposed North Atlantic service.

in this article, they will not find this problem as insuperable as it seemed a few months ago.

But will the oil companies also be obliged to step up their research and experimentation to discover new improvements in fuels beyond all previous calculation? If so, in what direction will these improvements be found? These questions loom large, and much of the answer will depend upon whether Congress decides that its air armament plans should be devoted as much to quality as to quantity.

Paradoxically, one of the most significant things about America's national defense program is the effect it will have upon the third classification of aviation—private flying. Ever since the economic debacle of 1929, when private flying took a terrible flop, it has been regarded as the weak sister of the industry. Yet, throughout, aviation leaders have realized that it held greater potentialities than the other two categories combined. The only question seemed to be—how to get the ball rolling, how to introduce the pleasures and utility of personal flying to those who could afford it.

For a long time, it has been recognized that probably the most fertile field for extensive cultivation is in the colleges. Yet, for some reason, the industry has always found it impossible to plow enough varsity ground and plant enough seeds to get anything like an ample crop of private fliers among college men. With the government launching its program to give flight training to 20,000 college students annually, it looks as though this rich soil is at last going to yield a real harvest.



Imperial Airways, which soon will be adding the North Atlantic route to its services, has its large flying boats operating over most of the world—the Canopus being fueled at Athens, Greece.

Photo courtesy aviation dept., Asiatic Petroleum Co. Ltd.

When it is considered that, after all these years, there are hardly more than 20,000 civilians holding active pilot licenses in the United States today, and that of these perhaps a majority are impecunious youngsters with an ambition to get into commercial aviation, it is easy to visualize what it is going to mean to private aviation to have added to the pilot roll each year 20,000 young men who, by and large, come from families financially able to own and operate an airplane.

Another factor which is painting brighter horizons on the private flying picture is the recent great growth in popularity of the light plane. Today, more than half of the nation's 10,000 registered civil aircraft are so-called flivver ships—two-seaters selling from $1,000 to $2,000 on the installment purchase plan, with a course in flying instruction thrown in for good measure. It used to cost about $1,000 for flight training alone, not to mention many thousands more to purchase an airplane. In 1935, only 436 of these little ships were manufactured. By 1937, they were being produced and sold at the rate of 1,500 per year. Several manufacturers report that already, in the first six months of 1939, they have sold more planes than during the entire year of 1938.

It becomes apparent that the snowball of private flying finally has started to roll. Before it stops, it may easily become the biggest and weightiest factor in the whole aviation industry. As it gains in size and importance, however, it inevitably will present problems to the petroleum industry which will be quite divergent from those of military and air transport aviation. For the most part, they will be problems of marketing and distribution, while for the military services and airlines, they will continue to be problems of producing fuel of high octane rating in commercial quantities sufficient to meet the demand.

For several years it has been common knowledge among oil companies and engine manufacturers that the efficiency and power output of aircraft engines can be greatly increased by raising the compression ratio. The principal limitation, however, has been in the quality of fuel available. The best fuel which could be produced in commercial quantities was 87 octane. Yet, for transport and military purposes, it was apparent that a truly substantial gain in efficiency and payload would come only with the adoption of engines designed to operate on 100 octane gasoline.

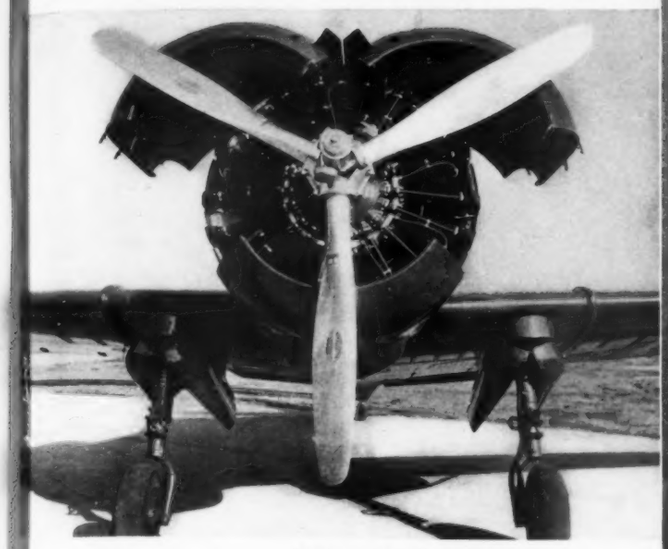
Until quite recently, however, even the most satisfactory process for producing 100 octane fuel was so complex and expensive as to be almost prohibitive. It depended upon the use of iso-octane as a blending agent, and the preparation of iso-octane involved a multiplicity of processes as well as operation at high temperatures and pressures. The result has been that, according to reports, only two air transport operators of the United States have found it feasible to use 100 octane at all. One of them, American Airlines, uses it only for the take-off from Los Angeles where its planes must make a steep, quick climb to get over the mountains. The other, Pan American Airways, uses it for trans-oceanic flying in the new 40 ton Boeings, because the non-stop distances flown are so great that the resultant saving in fuel load warrants the extra expense.

There is now a bright prospect that the airlines soon will adopt 100 octane almost universally, for research and development by a group of leading oil companies in collaboration has resulted in a new process by which 100 octane aviation gasoline can be produced in larger quantities at moderate cost.

This new method of producing 100 octane aviation gasoline is known as the Sulphuric Acid Alkylation Process. Broadly speaking, it involves a combination in the presence of sulphuric acid of one mol of iso-butane with

At present, 100 octane gasoline has its greatest commercial use for the ocean crossings, but it is also used by some concerns for the original take-off, with regular aviation fuel being consumed after the plane has achieved sufficient altitude.

Photos courtesy American Airlines



Photos courtesy Curtiss-Wright Corp.

The U. S. Army air corps is an important user of 100 octane fuel. Above—Close-up of a new 850 hp. engine which enables the plane to climb 5,000 ft. per minute, for intercepting enemy bombers. Right—The new supercharged high-speed Curtiss pursuit plane designed for use in the sub-stratosphere; all data on performance are withheld by the U. S. War Department.

one mol of butylene, under conditions of low temperature and pressure, to make one mol of alkylate which is largely composed of iso-octane. The composition of this alkylate is about 85 percent aviation gasoline of 92 octane.

When blended with 35 percent by volume of straight-run gasoline (72 octane), and 3cc. of tetraethyl lead per gallon, the alkylate yields an aviation fuel of 100 octane.

It is estimated that the investment cost of a plant to produce 100 octane aviation gasoline by this method would be considerably less than that required to produce iso-octane by the previous process. Moreover, because of low temperature and pressure, the operating costs of an alkylation plant will be equivalently low. Since the companies which developed alkylation are releasing rights to the use of their patents to the entire petroleum industry, it is probable that in the near future the supply of 100 octane aviation gasoline will become much more plentiful and the price such as to render it profitable for the air transport lines to make extensive use of this efficient fuel.

As for the U. S. Army Air Corps, in which 100 octane fuel is used almost exclusively, the problem has long been more a matter of supply than price. Fortunately, this new process comes just in time to meet the demands of a rapidly expanding Air Corps which will be consuming greater and greater quantities of aviation fuel. It may also prove to be a factor in inducing the U. S. Navy air service to adopt the more extensive use of 100 octane gasoline; thus far naval airplanes have operated on 87 octane.

While advances in the production of 100 octane gasoline in commercial quantities promise to meet the aviation industry's fuel needs, the problem of lubricants which can be subjected to the higher temperatures and greater loadings of high-compression engines using 100 octane fuel has not received an entirely satisfactory solution. For a time it seemed that compounded oils might hold the answer. The experience of European airlines which used them seemed to indicate that they had made possible longer periods between engine overhauls than was common among American air transport operators. Yet, as matters have turned out, compounds have been unable to fill the requirements of American engine manufacturers. Pratt & Whitney, builders of the powerful twin-row Hornet, apparently will not approve anything other than straight mineral oil. The Wright Aeronautical Corp., which makes the 1,500 hp. Cyclone, on the other hand approves of some compounded lubricants.

Meanwhile, steady improvements have been made in the refining quality of mineral oils for aviation purposes, and although operating experience with the high pressures of engine burning 100 octane fuel is still limited, it may be that present aero oils have a sufficiently high lubricating value and resistance to deterioration.

Aerial tankers have been made by converting Royal Air Force bombing planes with large tanks and special connections to enable them to refuel Imperial Airways flying boats in midair, and thus enable them to take-off with a greater load.

Photo courtesy aviation dept., Asiatic Petroleum Co. Ltd.

The flying wing plane is now appearing on the world's airways. The photo shows a new transport plane of the type over Southampton, England. Since these have been in operation it has been proved that to increase the power of the allwing plane, and hence the speed, has little effect on the cost per passenger mile due to the inherent aerodynamic efficiency of the design. Doubling power of one such plane failed to change the cost per passenger mile despite the increase in speed of 26 per cent and of 27½ per cent in operating cost per plane per hour. Considering that fuel consumption was doubled, this development should be of interest to the oil industry.

Photo courtesy S. R. Thompson, development engineer, Burnelli Aircraft Co.

Fireman adjusting burners at the Port Jerome Refineries in France. Left — Refinery sewer outlet before separators.

FRENCH DECREES

Impose Heavy Construction Outlay on Oil Companies

By E. J. André

UNTIL RECENTLY it was considered that the legislative edifice governing the French oil industry which had been built up by successive legislative and executive sets since 1918 was finally completed. Events of the past year, have caused government officials to put a new interpretation upon the relation of petroleum products to national defence and as a result the oil companies find themselves faced with new obligations imposed by the Deladier government involving additional heavy capital commitments.

In order to meet, in part at least, the needs of a greatly expanded air force, a decree issued early in the year requires that from now on, or as soon as necessary adjustments can be made, 300,000 tons of aviation spirit are to be produced annually by French refineries. This is 12 percent of total capacity. The time limit allowed for additions to plant in order to comply with this order is October 1st, 1942.

In order to ensure the rapid execution of this decree the government is offering a bonus of Fr. 400 to 600 ($10.60 to $15.90) per ton on all aviation spirit produced from now onward. To avoid placing too heavy a burden on the smaller plants it is provided also that these may obtain their quotas from the larger refineries, thus avoiding unnecessary duplication of equipment and an expenditure which it might be difficult for some refiners to meet.

Since none of the refineries was in a position to produce the stipulated amount of high-test aviation fuel, a large additional investment will be called for to provide new installations and processes for this purpose. Engineering staffs are now studying the numerous processes for producing high-test gasoline that have been developed within the past year or two and drawing plans for the needed additions to existing plants. Great secrecy is being observed, however, in regard to the processes and equipment to be adopted.

From present indications it appears probable that the burden of supplying the large amount of aviation fuel demanded by the government will be shouldered principally by the larger refineries, including those belonging to Standard Francaise des Petroles, which was reported to be first on the list of applicants, S. A. des Petroles Jupiter, Cie. Francaise de Raffinage, the Societé Generale des Huiles des Petroles, Berre and Pechelbronn. Others may join the list but those mentioned in all probability will provide the major part of the supply.

Another defence measure is the order stipulating that, in future, petroleum depots must be distributed in a rational way in all parts of the country in accordance with military requirements. This, in all probability, will involve displacing existing storage tanks and erecting new ones. As far as possible subterranean storage is to be encouraged although it represents a greater initial outlay. All reservoirs situated above ground are to be protected from aerial bombardment by the erection of lateral walls nearly as high as the tanks themselves and by adequate camouflage. Since the cost of this protection is nearly as great as that of the tanks themselves the opinion is expressed that future storage facilities will be placed below ground.

The cost of the changeover in storage methods and protection is estimated at Fr. 500,000,000 ($13,250,000). This cost will be borne by oil companies in the beginning but will be refunded through tax abatement.

Another project dictated by the war scare of last September and the successive crises that have arisen since is the construction of a pipeline from the Atlantic seaboard to Montarges which has been described previously by WORLD PETROLEUM. This line, which is intended to enable the army to obtain fuel supplies even though the refineries in the valley of the Seine or at Le Havre should be destroyed, is to cost roundly Fr. 200,000,000 ($5,300,000).

French Bunkering and Exports

	French Vessels		Other Vessels		Exports	
	Imported Refined	French Refined	Imported Refined	French Refined	Imported Refined	French Refined
			(hectoliters)			
Kerosene	29	25,716	39	41,351	10,387	1,113,806
Other refined oils	6	92	.....	110	.....	901
White Spirit	.....	.....	.....	2	.....	990
Gasoline, tourist	67,935	193,002	168	6,352	1,529,116	1,334,112
Gasoline, other	1,361	26,142	.....	.....	.....	.....
			(tons)			
Lubricating oils	6,830	5,192	757	3,693	8,081	20,767
Vaseline and Paraffine oils	1	.....	2	.....	2,133	101
Gas oil	34,820	73,701	666	5,074	580	143,770
Fuel oil	301,683	774,647	4,498	67,341	36	30,435
Road oil	.....	927	.....	339	214	40,092
Pitch	10	.....	.....	.....	.....	54
Petroleum coke	.....	.....	.....	.....	.....	.....
Paraffine	6	.....	1	.....	143	2,121
Vaseline	.....	.....	.....	.....	.....	.....
Butane	.....	.....	.....	.....	.....	1,934

So many obligations imposed simultaneously naturally have caused great concern among the oil companies operating in France. Under the plan adopted the expense of carrying out the program gradually will be refunded. Even so, the sums that must be disbursed in the near future may well have the effect of unbalancing the budgets of many companies. Besides this is the unsettlement due to so much state interference. In France the oil companies never have been allowed to work out their own salvation in peace, and every program laid down has been subject to change when a new administration has come into power.

Another change that has had a disturbing effect on the oil industry has been the suppression of the Office National des Combustibles Liquides—the Petroleum Department. While subject to frequent criticism by members of the oil industry, it has served as a steadying influence in the relations between the industry and the state and under the direction of Col. Louis Pineau it had come to be recognized as rendering an important constructive service to both.

French Consumption of Petroleum Products

Product	1938 Imported	Domestic Refineries	Total
		(hectoliters)	
Kerosene	15,689	1,496,633	1,512,322
Other refined oils	87	63,846	63,933
White Spirit	5	137,887	137,892
Gasoline, tourist	6,789,913	25,638,745	32,428,658
Gasoline, other	279,304	2,658,252	2,937,556
		(tons)	
Lubricating oils	50,235	172,942	233,177
Vaseline and Paraffine	1,424	877	2,301
Gas oil	53,059	272,948	326,017
Fuel Oil	102,342	1,167,075	1,269,417
Road oil	18,421	279,495	297,915
Pitch	3,542	2,512	6,054
Petroleum coke	36,400	1,175	37,575
Paraffine	794	3,824	4,618
Vaseline	38	2	40
Butane	178	41,339	41,537

Responsibility for elimination of the O. N. C. L. as an independent bureau rests primarily on M. de Monzie in his capacity as Minister of Public Works. While economy was given as a reason for the action, there was a widespread belief that more compelling cause was the desire of the Minister to have a free hand in making changes in the oil industry.

Among the developments in which the O. N. C. L. had figured prominently in the course of its existence was the accumulation of substantial war stocks, the construction of fifteen refineries and a fleet of tankers now registering 520,000 tons, the French participation in Iraq Petroleum Company, the foundation of the technical oil school at Strasbourg, the creation of research laboratories, the law requiring the mixture of alcohol with home-refined gasoline, the encouragement of national motor fuels and gasolenes, the production of benzol and synthetic fuels and the organization of the oil market by means of import licenses. This is an impressive list of achievements. Whatever their effect, they were conceived in the interest of the state. Not the least valuable asset of the bureau was the long experience and inventive spirit of Director Pineau. In the opinion of well informed observers the dismantling of the O. N. C. L. at a time of national stress was, to say the least, a step of doubtful utility.

Imports of Crude Oil Into France

Country of Origin:	1937 (in metric tons)	1938
Iraq	3,129,000	3,143,000
United States	1,247,000	2,316,000
Venezuela	528,000	643,000
Colombia	387,000	420,000
Peru	433,000	344,000
Ecuador	70,000	48,000
Roumania	181,000	56,000
Other Countries	177,000	19,000
	6,152,000	6,969,000

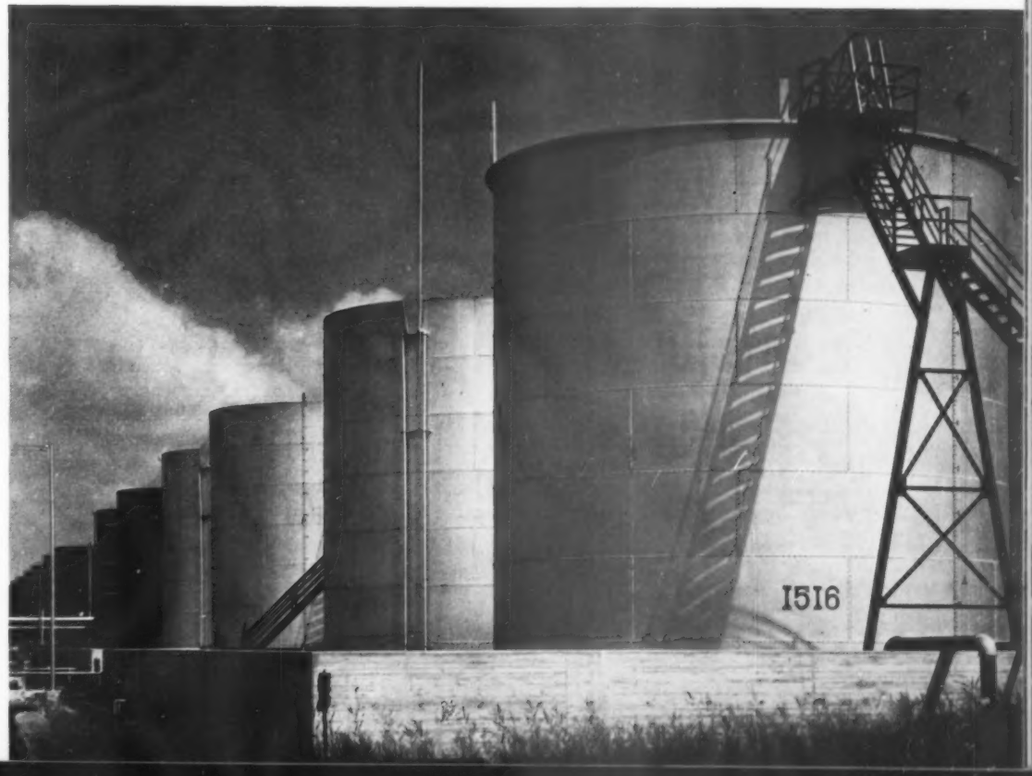
In spite of mounting taxation which has tended neither to help the motor trade nor the oil industry consumption of petroleum products in France has managed to show some increase. This has been due to the increasing size and use of commercial vehicles although the number of motor cars actually has decreased. Expanding military requirements presumably have played some part also in preventing a decline in imports and domestic demand. According to statistics recently published total imports of crude and refined products during 1938 amounted to 8,165,000 tons valued at Fr. 4,256,000,000 ($112,784,000). For the year preceding imports were 7,800,000 tons with a value of Fr. 3,132,000,000 ($82,998,000). This was an increase in volume of 4.5 percent and in value of 35.9 percent. Devaluation of the franc was responsible for the disproportionate rise in value.

French Imports of Refined Products

	1937 (metric tons)	1938
Aviation gasoline	531,621	508,842
Motor gasoline	75,812	21,009
Gas oil	214,928	94,942
Fuel oil	627,574	404,146
Lubricating oils	88,012	69,814
Road oils	28,853	18,480
Petroleum coke	32,116	39,951
Vaseline	45	38
Other refined petroleum	2,468	1,399
Vaseline and paraffine oils	892	1,426
Paraffine	809	800
Asphalt and Bitumen	6,737	3,485
Wax	120	84
Motor Benzol	32,375	29,400
Benzol for industrial use	11,774	2,097
	1,649,236	1,195,853

An accompaning table shows, the growth of refining capacity continued to be reflected during 1938 in larger imports of crude and declining receipts of refined products. Other tables show the preponderance of domestic refining over imports in the supply of products and the volume of products accounted for by bunkering and exports.

This row of storage tanks belonging to the Standard Française illustrates the enormity of the problem arising from the need for bomb-proofing.



TEN YEAR RECORD
of Voluntary Curtailment in California

By J. R. Pemberton, State Oil Umpire

As of today, there are 19,000 oil wells located in 112 separate oilfields in California, owned by 1,060 separate and distinct partnerships, individuals and companies. The productive depths of the wells range from 400 ft. to over 13,000 ft. The capacity to produce ranges from one barrel per day in some wells to indeterminate amounts, conservatively estimated to be perhaps as high as 25,000 bbl. daily, in others. There are oilfields with as many as eight separate and distinct productive zones, each of which comprises a separate oil pool. Ownership of wells ranges from individuals with a single well to Standard Oil Company of California which has more than 3,300. The ability of all of these wells to produce is estimated to be in excess of 2,000,000 bbl. daily, yet the consumptive demand for oil is around 600,000 bbl. daily.

There are in California a number of refineries owned and operated by companies owning oil wells, but there are also many refineries operated by those who do not. The problem of curtailing the production of the state to 600,000 bbl. daily involves compromises of all sorts between the non-well owning refiner, landowners whose sole source of income is from royalty oil, the promoter-well-owner improperly financed with a string of creditors on his back, and, last but not least, the strongminded individualist who refuses to cooperate with his brother producers and wants to get his profit quickly and go fishing.

Up to the present time the people of the state have refused to sanction laws for the regulation of production such as have been enacted in some other states. Such results as have been reached in keeping production within reasonable bounds have been attained by voluntary action. It is hoped that an account of the evolution of this voluntary program of self-management and stabilization may be of general interest.

Although considerable unpublicized curtailment had been practiced by some of the large companies since 1922, it was not until early in 1929 that the necessity for a broad scale curtailment became apparent. The large producing companies, during an intensive wave of development in extremely prolific and highly competitive oilfields in the Los Angeles Basin, notably Santa Fe Springs and Long Beach, finding their stocks of crude petroleum mounting by leaps and bounds, took the lead in reducing production for their own account on their fee-owned properties wherever owned in the State and endeavored to convince other operators of the necessity of likewise reducing their production. There was no definite program and the reduction was not enough, so a series of open meetings was held in which all operators were informed of the seriousness of the impending situation. Paul N. Boggs, of the Union Oil Company, assumed leadership of a curtailment movement and F. C. Van Deinse was appointed as the first Oil Umpire to arrange for the assembling of an organization and the issuance of actual schedules of production to producers.

While the start of voluntary curtailment had been made, the value of the movement was not appreciated by the independent producers and the program failed after two months trial. By October 1929 there were over 185,000,000 bbl. in storage. During that month the price for 27 gravity Signal Hill crude oil was cut from $1.13 to 60c. per barrel and many producers were without market for any of their oil at any price. Independent producers took things into their own hands and in mass meetings at Santa Fe Springs and Long Beach oilfields, named an Oil Umpire for each of their fields and actually curtailed as of November 1st, 1929. Production declined greatly; prices were restored, and in December, 1929, the Elwood and Ventura Avenue oilfields joined the curtailment movement. The operators in the four fields in which curtailment was being practiced, and the major companies which had voluntarily shut in a great deal of their own production on fee-owned properties, then took the lead in expanding the curtailment program to all fields in the state. In February, 1930, there was organized a formal group of oil producers called the General Committee consisting of 15 members, seven representing major companies and eight representing independent companies. The expansion of the curtailment program resulted in production being reduced from 880,000 bbl. daily in August, 1929, to 530,000 bbl. daily by December, 1930, and stocks of oil declined 11,000,000 bbl. for the same period.

During 1931, production continued to be reduced and by the middle of the year, the expense of operating the program was cut down by consolidating the two umpire offices into one. H. Paul Grimm, who had been the umpire for Santa Fe Springs, resigned in favor of Neal H. Anderson, who was the original umpire for Long Beach. While production of crude oil declined during 1931 to 500,000 bbl. daily by the end of the year and 5,228,050 bbl. of oil were withdrawn from storage, gasoline price wars commencing in March brought the price of crude down from $1.26 to 44c. by the end of April. This anomalous situation was caused by independent refiners purchasing non-curtailed oil at reduced prices from producers who were unable to sell to the purchasing companies which were supporting the curtailment movement. These so-called bootleg refiners, purchasing oil at prices below the market price, were therefore enabled to market gasoline well below posted prices. The situation became so serious that the first attempt to obtain the passage of a state law to control the production of crude oil was made and the legislature passed an oil control bill on May 4th, 1931. Gasoline price wars ended in June and the price of crude oil was raised to $0.75 per barrel at the end of July, 1931.

During 1938 California saw many changes take place affecting the oil industry, the first of which was a state-wide election on a referendum petition against the oil control bill on May 3rd, 1932. Due to violent opposition and clever propaganda against the bill, it was defeated by the voters. Following this the general committee which had been formed in February, 1930, resigned with the statement that they had done their best to effect curtailment, but, having obviously failed, they believed it well that the independent producers themselves carry on henceforth without the leadership of the major companies. The consensus was that any program of curtailment which the independent producers should agree upon and carry out would find the major oil companies adhering to figures on the same basis as the independents.

Neal H. Anderson, the oil umpire, then (in May 1932) organized the independent producers under a program which has been carried out from that date until the present. The program consisted essentially in dividing the state into 13 producing districts: in each district each producer, exclusive of the major oil

California Production Statistics

Year	Production Barrels	Production Barrels Daily	Stocks at End of Year	Stocks Increase or Decrease	Utilization Barrels	Utilization Bbl./Day
1926	224,117,013	614,019	145,255,269	−12,244,731	236,361,744	647,566
1927	230,751,463	632,196	138,263,637	− 6,991,632	237,743,095	649,983
1928	231,982,597	635,569	138,265,857	+ 2,220	231,980,377	636,931
1929	292,036,911	800,101	183,615,201	+45,349,344	246,687,567	675,856
1930	228,099,899	624,931	175,273,100	− 8,342,101	236,442,000	647,786
1931	188,829,032	517,340	170,045,050	− 5,228,050	194,057,082	531,663
1932	178,127,794	486,688	168,217,671	− 1,827,379	179,955,173	491,681
1933	173,083,319	474,201	155,441,159	−12,776,512	185,859,831	509,205
1934	175,508,566	480,845	130,171,939	−25,269,220	200,777,786	550,076
1935	207,835,131	569,403	135,362,388	+ 5,190,449	202,641,682	555,183
1936	214,773,315	586,818	136,781,015	+ 1,418,627	213,354,688	582,912
1937	238,520,383	653,481	133,595,271	− 3,185,744	241,706,127	662,506
1938	249,124,508	682,533	158,905,036	+25,309,765	223,814,743	613,191

Pemberton - Oil Umpire

In 1932 it looked as though the budding effort to establish some degree of order in the California oil industry were doomed to failure. Two committees, set up to encourage voluntary curtailment among producers, were in conflict. Agreement seemed impossible and the oil umpire who for three years had been giving his best efforts to the cause resigned.

In the discussion as to his successor the name of Bill Pemberton was mentioned. The two committees quickly accepted him and he has been on the job ever since.

Pemberton brought a good equipment to the position. He is a big man mentally and physically, standing six-foot-four, athletic and in the prime of life. Born in Los Angeles, educated at Stanford University where he played football, rowed and was something of an amateur boxer, he graduated in 1909 as a geologist. After a brief service with the U. S. Geological Survey he was employed by the government of Argentina and spent five years classifying the public lands of Patagonia.

Returning to California, he acted as district sales manager for a local refining company, then went to Oklahoma where he helped to develop a successful producing company. His next association was with the late Edward L. Doheny, first as a geologist and later as general manager of all field operations for the Petroleum Securities Company, owned by the Doheny family.

This varied oil experience has been extremely valuable to Mr. Pemberton in his present position. An umpire occupies no bed of roses, either in the oil business or on the playing field. Pemberton speaks the oil man's language and backs up plain talk with a vigorous, straightforward personality. Through many vicissitudes he has kept the work of voluntary regulation moving forward in California and has commanded the respect of the oil fraternity while doing it.

companies, had one vote in the election of a committee to represent the district. Each committee after the election then elected a chairman and the 13 chairmen thus elected met on May 19th, 1932, and organized themselves as the central proration committee. This committee was shortly afterward assisted by another committee called the executive committee for equitable curtailment, composed of three members from each of two independent-producer trade associations and four members from the central proration committee. These two committees instead of working in harmony, immediately clashed on policy and Neal H. Anderson, the umpire, who had organized the whole curtailment program, resigned on July 8th, 1932. On July 13th, 1932, a harmonious conclusion of their difficulties was reached and a new oil umpire, J. R. Pemberton, was appointed.

It would be interesting to trace the ups and downs of the voluntary curtailment program during the seven years following but space prevents more than a brief summary.

The year 1932 was stable. Crude prices rose to $1.00 in June. Production during the final month of the year was 465,000 bbl. daily and stocks were reduced slightly. In 1933 a change in organization was made by increasing the number of electoral districts from 13 to 18 and allowing the major oil companies to be represented. The central proration committee changed its name to the central committee of California oil producers and appointed a subcommittee to study methods of improving the proration system.

During the period of the N. R. A. the central committee, by appointment of petroleum administrator Ickes, acted as the federal agency for administering the code then in effect. The price of crude was maintained at $1.00 and by the end of 1934 stocks had fallen to 130,000,000 bbl., the lowest in ten years.

Gasoline wars broke out in June, 1935, following the break-up of the N. R. A. The major companies had been taking the output of independent refiners, or that part of it for which the owners could not find a ready market, but discontinued the practice for fear of contravening the anti-trust laws. Production mounted from 492,000 bbl. daily during the final month of the N. R. A. regime to 628,000 bbl. in the following September. The crude price was cut in half. After an unsuccessful effort to bring about the adoption of a contractual agreement among producers the central committee suspended operations. Production rose to 672,000 bbl. daily in December, 1935, and 12,000,000 bbl. were added to storage during the final quarter of the year.

In the meantime a group of independent producers met and formed an emergency advisory board which included the independent members of the central committee. It was decided to maintain the office of the oil umpire, to issue schedules on a three months basis and continue keeping records.

Early in 1936 producers were so wearied by the battle that the central committee was urged to resume operation. Production was held to an average of 586,000 bbl. daily for the year, the crude price rose to $1.10 and the rate of additions to storage was retarded.

Because of war in the Orient and other factors, the demand for California oil increased beyond all expectations in 1937. Although new and prolific fields were brought in and production rose above 700,000 bbl. daily the high level of consumption prevented the situation from becoming acute although it was easy to see that a crisis would confront the industry as soon as the extraordinary demand began to slacken and early in 1938, with production up to 734,000 bbl. daily and stored stocks mounting it became clear that the industry was heading for serious trouble unless a check could be applied. Mass meetings of producers were held, emergency committees were appointed and the drive succeeded in bringing daily production down to 617,000 bbl. the last week in December.

Probably at no time in the history of California's voluntary curtailment has the interest among producers been so great as in the first half of 1939. Not only oil producers but landowners, refiners, bankers, supply men and others concerned with the prosperity of the most important industry in California have participated in meetings to consider the situation. During the first four months of the year production averaged 624,000, 622,000, 626,000 and 615,000 bbl. daily. Despite the decline in consumption only 3,600,000 bbl. went to storage. Compared with the bad situation existing throughout 1938 the progress made was highly satisfactory.

© Inman

Long Beach Harbor oilfield, looking east from the Southern California Edison plant.

The extent of the interest aroused was reflected by the introduction in the legislature of two bills providing for state control of the industry but these have not caused voluntary efforts to slacken. The central committee has been reconstituted by enlargement of its membership to 31, of whom 28 represent local districts and three represent the main producing districts of the state, the San Joaquin Valley, the Coastal districts and the Los Angeles Basin. At a meeting of the committee on May 17 unanimous agreement was reached on a new method of calculating curtailment ordered effective for the month of June.

As now constituted the voluntary organization consists of 28 field committees, the central committee and the oil umpire.The central committee is the active governing body. Its members are selected in the following manner:

The secretary of the committee, upon orders of the committee, issues to each producer in each district a ballot with the request that he nominate from his district a number of individuals, the number not to exceed 10 percent of the total producers in the district and in any case be not less than five members. The producer, after marking his ballot, places it in a blank envelope labeled on the outside "ballot" and this sealed ballot is placed in a stamped, addressed envelope, with the name of the voter on the outside of the envelope, and mailed to the secretary. The secretary records those who have voted, tabulates the nominees of all of the nomination ballots and these names are placed upon a final ballot for the election. The final election ballot, upon which instructions call for voting for one name as chairman, one for vice-chairman and some three or more for committeemen, is sent to each producer in each district by registered mail with return receipt requested, making certain that the ballot has been received. The producer then marks the ballot, places it in a blank envelope marked "ballot" and places this in a stamped, addressed envelope and it is mailed to the secretary. An election committee, previously appointed by the central committee, meets on a designated date, tallies the votes and certifies to the central committee the representatives elected in each district. A meeting of the representatives so chosen is called, a chairman and other officers are elected and general organization matters attended to. Sub-committees are appointed and their duties outlined. At the present time, as in the past, the principal sub-committee is the allocation committee, consisting of five members of the central committee. This is the working committee and meets as many times each month as is necessary for the purpose of examining into and studying all phases of the current situation with the object of recommending to the central committee at its next regular meeting any action which they believe should be taken.

The central committee appoints the oil umpire as the administrative officer of the curtailment program to carry out the official rules and orders as issued. The principal function of the oil umpire is to keep statistics. These consist of the official name of each operating unit in the state, the names of the officers and the addresses of the companies, the name of each well owned by the company with all data possible bearing on the well, including such facts as location, depth, casing, perforations, tubing and manner of production. The umpire also keeps a record of the estimated total potential capacity of the well under normal and reasonable methods of operation, the recommended quota of oil production or allotment that is issued for the well each month, the number of barrels actually produced during the month, the amount of oil in storage at the end of the month for each lease or well as the case may be, to whom oil is sold and how much is sold. These data are kept on cards, in standardized typewritten forms and graphic curves. The records of the umpire's office were sketchy during the first two years of operation but became standardized by the end of 1931 and in the office can be found a nearly complete record of everything of importance concerning the operation of any oil well within the state. On flowing wells record is kept of the gas production; the size of the flow beans, casing and tubing pressure. Not an item of information is neglected if it can be obtained.

Employees in the umpire's office have varied from 45 to 75, depending upon the year. During the N. R. A. period the number was highest. Normally from 45 to 50 people are employed to carry on the program.

The essential organization consists of:

1. Field committees of elected operators with chairmen in each important oilfield or group of smaller fields composing a district.
2. A central committee consisting of the chairmen of all of the field committees; and
3. The oil umpire.

Each of these has a separate function. The

central committee, aside from the authority to appoint the oil umpire, has two main duties: the first is to adopt recommended quotas of production for the entire state each month; the second is the adoption of a formula or method by which the state quota is to be divided to either all of the wells of the state or all of the fields of the state. In the adoption of a state quota, it is customary to set a figure based upon the outlook for the succeeding month. This of course is affected by three things: (1) season of the year, there being vastly more oil necessary in summer than in winter; (2) the fact as to whether oil is going into storage or being withdrawn from storage; (3) recommendations or forecast by the U. S. Bureau of Mines.

Naturally the recommended quotas of production to producers are not universally complied with and when a quota is set for the state, it is anticipated that actual production will be larger and allowances are made for this excess.

The function of each field committee is through meetings usually held every month to discuss with the operators in their field any and all problems that may be brought up. It is customary for operators, when something in the statewide curtailment program becomes objectionable to them, to endeavor by a majority vote to convince their field committee chairman and representative on the central committee that a stand should be taken in the central committee meeting to reflect their wishes. The field committee also acts as a board of review in the question of disagreements between operators and the oil umpire as to potentials of wells. It has been customary also to allow each field committee to make the rules used in establishing potentials on the wells in their fields. The oil umpire attends as many field committee meetings as possible with the object of endeavoring to standardize all actions of these committees. In general, the entire curtailment program must meet with the approval of each field committee or it will fail. So, great stress is placed upon the importance of the meetings of the field committees and their constituent operator-voters.

The oil umpire keeps all the statistics and carries out the orders of the central committee. The only definite authority of a discretionary nature with which the umpire is endowed is the establishment of potentials of wells. The engineers of the oil umpire's office, through study of the history of each well in the state, the production record of which is expressed graphically, apply a decline in its ability to produce each month commensurate with the actual performance of the well under its operating characteristics. The potential of a well is supposed to be the amount of oil which that well could produce daily for one entire month under normal operating conditions, without damage to the well or waste of gas. Naturally the true potential of any well is never known unless the well be one which is exempt from curtailment because of its small size and therefore its total production during a month, divided by the number of days of the month, is its true potential. Potentials are estimates, which estimates however are based upon facts. As long as the estimated potential of a competing well is relatively correct, no harm results. An error on one well in a group of competing wells, however, immediately brings a protest by the other producers in case the error was on the high side. If the error is on the low side the remonstrance is by the owner of the well. In treating the potentials of some 19,000 wells in California, one not acquainted with the working of the curtailment program would marvel at the nearly complete absence of friction that results between the operators and the engineers of the umpire's office. It has always been a surprise that potentials are set each month with nearly universal acceptance by all of the operators. In those rare cases where disagreement occurs, the matter is first referred to the field committee, it being assumed that the producers in any one field are apt to be best informed about conditions in their own area, and may be expected to settle the question. When neither side is satisfied, following a review by the field committee, the operator has the privilege of making a capacity flow test to demonstrate the actual facts. A flow test is supposed to be conducted while all neighboring wells are producing at their allotted rate and following a period of a week or more during which the well in question has been producing at its allotted rate. The duration of a flow test may be from a few hours on a large flowing well to three days on a medium-sized well and from three to ten days on a pumping well. But once a flow test has been completed, there is no argument possible on any side. In hundreds of flow tests which have been made, the outstanding fact has been that the great majority of those tests substantiate the potential estimates as carried by the umpire's engineers.

The expense of conducting the program involves salaries for the umpire's staff, including field men, inspectors and gaugers; office rent,

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Scenic twilight shot on the Frank J. Dore No. 1, drilled by the Hathaway Company in the West Montebello field, California.

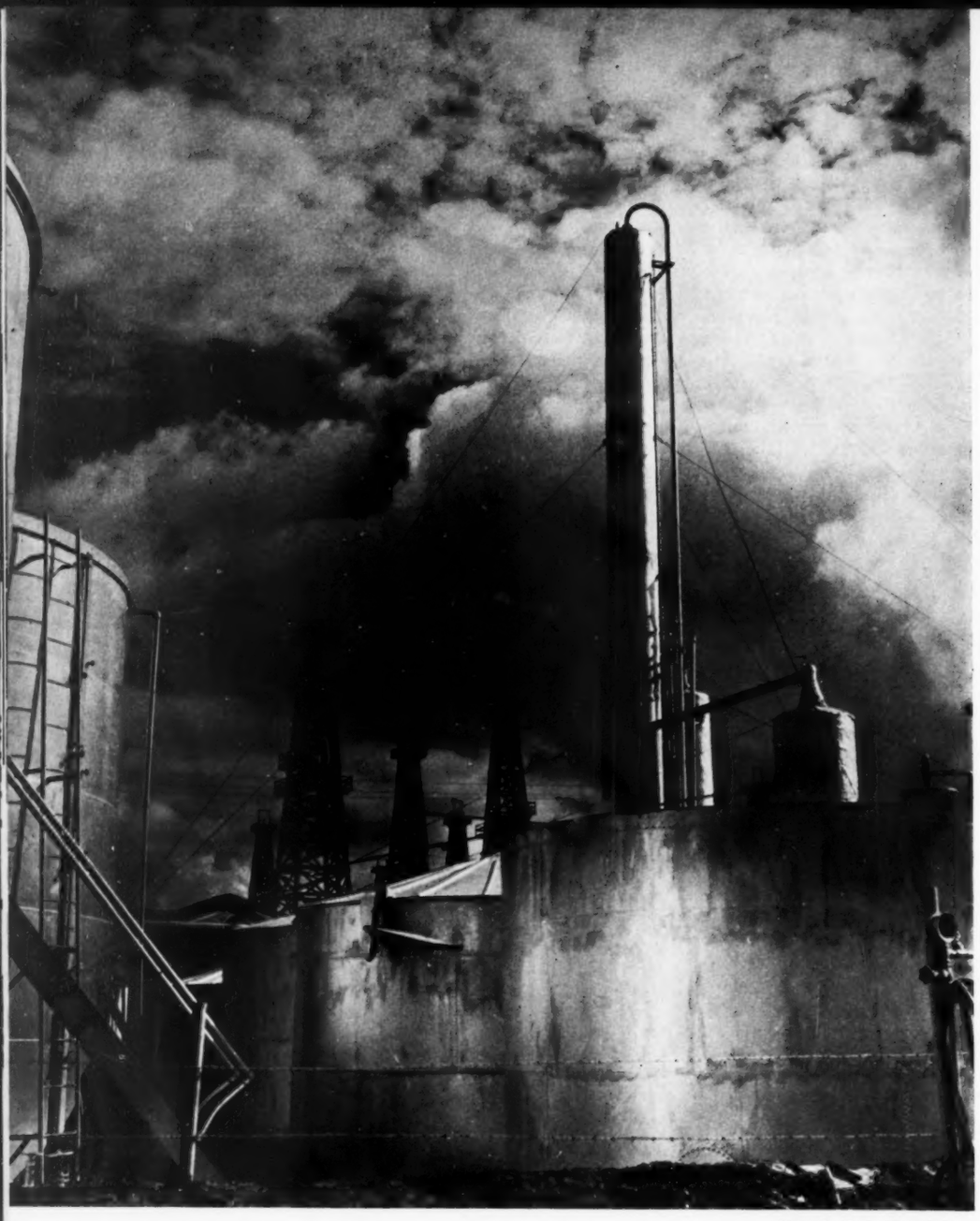

Photo by Cy La Tour & Son

During the past 10 years an average of 223 producing wells have been abandoned annually in the California fields.

supplies and all of the conventional expenses in the maintenance of an office. The expense amounts to about $200,000 per year and is borne by the operators themselves, each operator being assessed each month for an amount based upon his actual production for the preceding month. There is no obligation on the part of an operator to pay his assessment and many do not pay even though they adhere religiously to their quota. Thus, those who pay, must pay an increased assessment to balance the failure to pay by others. At present the assessment is $.00125 per bbl. or $1.25 per 1,000 bbl. It has been estimated that the statistics alone which a paying producer is privileged to obtain each month from the umpire's office, would cost any company more than its pro rata share of maintaining the office, if the company elected to maintain its own statistical bureau. Assessments are paid regularly by some producers who do not curtail, simply to obtain the statistics.

OPERATION

In the latter part of each month, the central committee meets and, guided by the recommendations of the sub-allocation committee, adopts a quota of production for the ensuing month and also a method of division of this quota to all of the fields and pools of the state. In the establishment of a quota, it is necessary to increase the previous month's quota by the amount necessary to give allotments to all new wells which were completed during that month and which have not as yet had an allotment and to decrease the preceding month's quota by an amount equal to the decline in productivity of all of the pools of the state and then to reduce or increase pro rata all fields in order to equal the newly adopted state quota.

The oil umpire then computes and issues the allocation schedules of production for each oil field. Upon these schedules is listed the names of all of the operators in alphabetical order; the names and number of all of their wells and the respective potentials and producible allotments of the wells. These schedules are then mailed to each producer with explanatory letter. The issuance of schedules is carried out principally by the engineering staff, followed of course by stenciling, printing and mailing. During every day in the year, there is tabulated the preceding day's production by operators, wells and fields. This is accomplished by agents of the umpire's office collecting in fields the needed information. Other data is obtained by telephonic communication between the office and the operators themselves. Thus a daily record of production is available at all times and the record of production of any operator or any well can be ascertained for any particular period, be it one day, a week or any part of a year. Printed, tabulated, daily records are kept of the principal fields and producers that are in the limelight. Another department of the umpire's office during each month tabulates the final reports of production under the title—net production. These reports consist in tabulating the actual shipments of oil from each well in the state to the purchaser and the amount of oil in storage on the lease at the beginning and end of the month, from which can be calculated the exact production of the producer during the month. Net production figures are the final ones and are computed always one month later than are the daily production figures. The net production consistently averages about 2½ percent lower than the daily production, the difference probably being accounted for by overestimates, loss, water, emulsion, deductions and temperature settlings and various other reasons. Following the completion of the net production there is issued a summary of production for each field in the state by operators and leases in which is tabulated the allotment for each well and the actual production, accompanied by a balance of either excess production or shortage as the case may be. There is also issued for each month in the year a summary of the state as a whole in which the allotments, production by fields, shipments and takings from fields both by producers and purchasers are all tabulated. At the end of each year there is also issued an annual report giving a written outline of the year's happenings accompanied by statewide statistics of every nature, including the total production of each company during the year, compared with its allotment, number of wells, potential and other interesting information. Thus at any time a rather complete statistical picture can be given bearing upon any operator, well, lease or field in the State.

CALCULATING

In the beginning of 1930, the method employed was to convene the operators of a field and request that its production be reduced

by a specified amount. If the operators concurred, they would then agree among themselves upon some way of accomplishing the desired result, usually by assigning a compromise figure to each producer. As time went on and all of the fields of the state were asked to curtail to some extent, it became customary for the committee to set the quotas for each field. The field committee would have previously met and adopted a method by which their quota, whatever it be, was to be divided by the umpire to the wells in the field, From the time this practice started in 1932. until the month of June 1939, the whole meat of curtailment was in the establishment of these field quotas. The theory under which calculations were made was that there should first be allotted to every well a minimum allotment, which was always based upon the depth of the well, the minimum increasing with depth. The minimum allotment was five barrels per 1,000 ft. of depth and served to exempt from curtailment the small stripper wells. For wells with potential greater than their minimum allotment, which amount is termed remaining potential, there was issued a remaining allotment which, added to the minimum allotment, becomes the producible allotment of the well. The theory of curtailment has been that very little restriction should be applied to small wells with the highest degree of curtailment to the large wells. The quota of a field was customarily calculated by dividing the total potential of the field by the total number of wells to obtain the average well size. The average well depth is also known. Then a scale of graduated curtailment was adopted, based upon the application of a power factor to the average remaining potential of the average well of each field. It was impossible to apply straight percentage, because too much oil would be assigned to large wells and too great curtailment would be applied to little wells, so the theory of a power factor graduation seemed to fit the case. From this, the total allotment to the average well of each field, multiplied by the number of wells in each field, gave the total quota of the field.

This whole system of graduation was used to determine what the theoretical and equitable curtailment should be on every field and was used solely as a guide, compromises having at all times been necessary to compensate for all sorts of conflicting factors. Few field quotas were at any time equal to the amount which could be calculated on the previously outlined method. Toward the end of 1938 through gradual adjustment to parity and to uniformity of a degree of curtailment based on the graduation method, the closest approximation to the theoretical curtailment that had ever been in effect, resulted. A modification of the graduated form of curtailment was placed in effect in April, 1937, when a top allotment of 400 bbl. daily was assigned to all big wells. This came about through the sudden, great increase in wells with potentials too high to consider. Therefore a top allotment was fixed and beginning with a potential of 2,000 bbl. daily, no well regardless of potential in excess of that amount received any more allotment. This top allotment has been reduced gradually from the first top allotment of 400 bbl. daily until at present it is 250 bbl. daily. It has been felt that the top allotment is justified because it prevents competition among operators for excessive potentials and also that amount should be sufficient to permit comfortable operating profits commensurate with the capital cost of the well.

The subject of the top allotment assigned new, big wells necessitates discussion of all new wells. New wells are being drilled constantly and I suppose there is no way to avoid

Six wells may be drilled from a single foundation, by means of controlled directional drilling, with an expenditure for piling, etc., only double that required for a single well.

Courtesy Petroleum Conservation Division of Dept. of the Interior

this. Generally speaking, it is necessary that adequate underground reserves be maintained by the industry at all times and certain it is that the larger integrated companies must maintain their own reserves so as to warrant a continuity of business. There is shown here a table of results of drilling in California, giving some statistics on drilling for the past 10 years and showing that an average of 223 producing wells are abandoned each year. The average potential of such wells is small as of the date of abandonment, probably averaging from one to five barrels daily, so that the total potential lost by the abandonments is around 1,000 bbl. daily in one year.

I have explained elsewhere that the normal decline in all of the producing wells of the state amounts to about 9,000 bbl. daily, dependent to some extent upon the rate of production, the decline having been higher when more than 700,000 bbl. daily were being produced and considerably lower when production was around 600,000 bbl. daily. The table shows for 10 years the average number of new wells completed was 644 per year and that the average initial potential was 955 bbl. daily. The outstanding feature of the table is that in spite of more than an average number of wells completed in 1936, the average potential per well was the lowest for 10 years, being less than one-half of the 10-year average. This very lack of comparative success led to the great wave of exploration in 1937 and 1938 which resulted in the discovery of 15 new oil fields with accompanying additional reserves, and 1937 and 1938 show the completion of the greatest number of wells ever completed in any two-year period while 1938 had the third highest average potential within history. Thus great inroads had to be made in the allotments to the old fields to make room for these new wells and this was the cause of the adoption of the top allotment for wells in April, 1937, and the gradual reduction of that figure down to 250 bbl. early in 1939. The outlook for a continuation of drilling must be viewed from the point of view of the average. California is commencing to feel the effects of the law of diminishing returns and it is my belief that drilling will slacken and ease off and that the problem of further reducing wells in old fields to make room for new wells will be accomplished by decline and reduction of top allotments. The odds are against a continuance of discoveries and new development paralleling that of 1937 and 1938.

Allocation Table, June, 1939

POTENTIAL	ALLOTMENT according to DEPTH										
	0-2000'	3000'	4000'	5000'	6000'	7000'	8000'	9000'	10000'	11000'	12000'
5	5*	5*	5*	5*	5*	5*	5*	5*	5*	5*	5*
10	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*
11	11*	11*	11*	11*	11*	11*	11*	11*	11*	11*	11*
15	13.9	15*	15*	15*	15*	15*	15*	15*	15*	15*	15*
18	15.4	18*	18*	18*	18*	18*	18*	18*	18*	18*	18*
20	16.3	19.7	20*	20*	20*	20*	20*	20*	20*	20*	20*
25	18.4	22.4	25*	25*	25*	25*	25*	25*	25*	25*	25*
26	18.8	22.9	26*	26*	26*	26*	26*	26*	26*	26*	26*
30	20.4	24.6	28.9	30*	30*	30*	30*	30*	30*	30*	30*
35	22.2	26.6	31.3	35*	35*	35*	35*	35*	35*	35*	35*
40	23.9	28.5	33.4	38.4	40*	40*	40*	40*	40*	40*	40*
45	26.	30.2	35.4	40.8	45*	45*	45*	45*	45*	45*	45*
50	27.	32.	37.2	42.8	48.4	50*	50*	50*	50*	50*	50*
56	29.	34.	39.3	45.1	51.2	56*	56*	56*	56*	56*	56*
60	30.	35.	41.	46.6	52.8	58.9	60*	60*	60*	60*	60*
68	33.	38.	43.	49.3	55.8	62.6	68*	68*	68*	68*	68*
70	33.	39.	44.	50.0	56.6	63.4	69.7	70*	70*	70*	70*
80	36.	41.	47.	53.	59.9	67.2	74.6	80*	80*	80*	80*
81	36.	41.	47.	53.	60.	67.6	75.0	81*	81*	81*	81*
90	39.	44.	50.	56.	63.	70.6	78.5	86.3	90*	90*	90*
95	40*	45.	51.	58.	65.	72.	80.2	88.4	95*	95*	95*
100	41.	47.	52.	59.	66.	74.	82.	90.4	98.4	100*	100*
110	44.	49.	55.	62.	69.	77.	85.	93.9	102.8	110*	110*
120	46.	52.	58.	64.	72.	80.	88.	97.	106.6	115.8	120*
126	48.	53.	59.	66.	73.	81.	90.	99.	108.6	118.2	126*
130	49.	54.	60.	67.	74.	82.	91.	100.	110.	119.8	128.9
140	51.	57.	63.	69.	77.	85.	94.	103.	113.	123.3	133.4
150	54.	59.	65.	72.	79.	88.	97.	106.	116.	127.	137.2
160	56.	61.	67.	74.	82.	90.	99.	109.	119.	130.	141.
170	58.	64.	70.	77.	84.	93.	102.	111.	122.	132.	144.
180	60.	66.	72.	79.	87.	95.	104.	114.	124.	135.	147.
190	63.	68.	74.	81.	89.	97.	107.	116.	127.	138.	150.
200	65.	70.	76.	83.	91.	100.	109.	119.	129.	141.	152.
210	67.	72.	79.	86.	93.	102.	111.	121.	132.	143.	155.
220	69.	75.	81.	88.	96.	104.	114.	124.	134.	146.	158.
230	71.	77.	83.	90.	98.	106.	116.	126.	137.	148.	160.
240	73.	79.	85.	92.	100.	109.	118.	128.	139.	150.	163.
250	75.	81.	87.	94.	102.	111.	120.	130.	141.	153.	165.
260	77.	83.	89.	96.	104.	113.	122.	133.	143.	155.	167.
270	79.	85.	91.	98.	106.	115.	125.	135.	146.	157.	170.
280	81.	87.	93.	100.	108.	117.	127.	137.	148.	160.	172.
290	83.	89.	95.	102.	110.	119.	129.	139.	150.	162.	174.
300	85.	91.	97.	104.	112.	121.	131.	141.	152.	164.	176.
320	89.	95.	101.	108.	116.	125.	135.	145.	156.	168.	181.
340	93.	99.	105.	112.	120.	129.	139.	149.	160.	172.	185.
360	97.	102.	109.	116.	124.	133.	143.	153.	164.	176.	189.
380	100.	106.	113.	120.	128.	137.	147.	157.	168.	180.	193.
400	104.	110.	116.	124.	132.	141.	150.	161.	172.	184.	197.
420	108.	113.	120.	127.	135.	144.	154.	165.	176.	188.	201.
440	111.	117.	123.	131.	139.	148.	158.	169.	180.	192.	205.
460	115.	120.	127.	134.	143.	152.	162.	172.	184.	196.	209.
480	118.	124.	131.	138.	146.	155.	165.	176.	187.	200.	213.
500	122.	127.	134.	141.	150.	159.	169.	179.	191.	203.	216.
520	125.	131.	137.	145.	153.	162.	172.	183.	194.	207.	220.
540	128.	134.	141.	148.	157.	166.	176.	186.	198.	210.	223.
560	132.	138.	144.	152.	160.	169.	179.	190.	201.	214.	227.
580	135.	141.	148.	155.	163.	173.	183.	193.	205.	217.	231.
600	138.	144.	151.	158.	167.	176.	186.	197.	208.	221.	234.
650	147.	152.	159.	167.	175.	184.	194.	205.	217.	229.	243.
695	154.	160.	166.	174.	182.	192.	202.	213.	224.	237.	250.
750	162.	168.	175.	183.	191.	200.	210.	221.	233.	246.	
775	166.	172.	179.	187.	195.	204.	214.	225.	237.	250.	
800	170.	176.	183.	190.	199.	208.	218.	229.	241.		
855	179.	184.	191.	199.	207.	217.	227.	238.	250.		
935	190.	196.	203.	211.	219.	228.	239.	250.			
1,010	201.	207.	214.	222.	230.	240.	250.				
1,080	212.	218.	224.	232.	241.	250.					
1,145	221.	227.	234.	241.	250.						
1,205	229.	235.	242.	250.							
1,265	237.	243.	250.								
1,315	244.	250.									
1,360	250.										

* SAME AS POTENTIAL (ALL ABOVE RULE)

Results of Drilling in California

Year	Producers Abandoned	New Producers Completed	Initial Production	Average Potential New Wells
1929	212	910	1,307,496	1,437
1930	320	755	584,521	775
1931	177	246	364,434	1,481
1932	172	184	156,823	852
1933	215	248	274,104	1,105
1934	200	449	534,508	1,190
1935	203	710	677,320	954
1936	208	786	370,227	471
1937	273	1,156	647,331	560
1938	252	994	1,234,482	1,242
10-Yr. Av.	223	664	615,125	955

CURRENT SITUATION

The drive for curtailment, which was started in December, 1938, accompanied by the study of the petroleum fact finding committee, led to a recommendation by that committee that the system of programming curtailment which had been in effect since 1930 be abandoned and that a uniform formula applicable to wells only be adopted. It will be recalled that the state quota each month was divided into field quotas upon a compromise basis and whereas there had been during 1938 an attempt to balance the quotas so issued one against the other with the object of having such quotas fit a form of graduation applied to the average well of each field, that the actual allotment to wells in all fields had been left to the field committees each of which might adopt this formula. The result of all this was that wells of the same capacity and depth in different fields had different allotments. In order to correct this a uniform formula was recommended. The central committee, following the receipt of the report in March, gave more than two full months to an intensive study of all suggested uniform formulae and finally, on May 17th, adopted one which met with almost unanimous approbation of all producers throughout the state. Therefore, as of June, 1939, California has taken a new step in programming curtailment, wherein allotments to similar wells throughout the state will be the same. This formula is as follows:

To each well is first assigned a minimum

Orderly arrangement of steel derricks at the Huntington Beach oilfield, California.

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Potential Grouping of Wells According to Size All Wells in State as of April 1, 1939

POTENTIAL GROUPS	NO. OF WELLS	POTENTIAL B/D	POTENTIAL ACCUMULATED TOTALS LARGEST TO SMALLEST WELLS	POTENTIAL ACCUMULATED TOTALS LARGEST TO SMALLEST BARRELS	POTENTIAL ACCUMULATED TOTALS SMALLEST TO LARGEST WELLS	POTENTIAL ACCUMULATED TOTALS SMALLEST TO LARGEST BARRELS	POTENTIAL B/D PER WELL	MINIMUM ALLOTMENT * B/D	MINIMUM ALLOTMENT * B/D ACCUM. LARGEST TO SMALLEST	MINIMUM ALLOTMENT * B/D PER WELL	REMAINING POTENTIAL B/D	REMAINING POTENTIAL B/D PER WELL	POTENTIAL GROUPS
MINIMUM WELLS	7,844	52,825	18,698	1,946,091	7,844	52,825	6.7	52,825	232,056	6.7	-		
0 - 10 B/D	936	6,560	10,854	1,893,266	8,780	59,385	7.0	4,384	179,231	4.7	2,176	2.3	0 - 10 B
10 - 15	948	11,546	9,918	1,886,706	9,728	70,931	12.2	6,119	174,847	6.5	5,427	5.7	10 - 15
15 - 20	782	13,042	8,970	1,875,160	10,510	83,973	16.7	7,260	168,728	9.3	5,782	7.4	15 - 20
20 - 25	764	16,548	8,188	1,862,118	11,274	100,521	21.7	9,203	161,468	12.0	7,345	9.6	20 - 25
25 - 30	691	18,361	7,424	1,845,570	11,965	118,882	26.6	10,290	152,265	14.9	8,071	11.7	25 - 30
30 - 40	1,089	35,897	6,733	1,827,209	13,054	154,779	33.0	18,339	141,975	16.8	17,558	16.1	30 - 40
40 - 50	797	34,760	5,644	1,791,312	13,851	189,539	43.6	14,939	123,636	18.7	19,821	24.9	40 - 50
50 - 75	1,292	77,742	4,847	1,756,552	15,143	267,281	60.2	25,082	108,697	19.4	52,660	40.8	50 - 75
75 - 100	751	63,952	3,555	1,678,810	15,894	331,233	85.2	15,606	83,615	20.8	48,346	64.4	75 - 100
100 - 150	821	98,174	2,804	1,614,858	16,715	429,407	119.6	17,103	68,009	20.8	81,071	98.7	100 - 150
150 - 200	496	84,828	1,983	1,516,684	17,211	514,235	171.0	10,550	50,906	21.3	74,278	149.7	150 - 200
200 - 300	456	109,415	1,487	1,431,856	17,667	623,650	239.9	10,394	40,356	22.8	99,021	217.2	200 - 300
300 - 400	212	71,726	1,031	1,322,441	17,879	695,376	338.3	5,249	29,962	24.8	66,477	313.6	300 - 400
400 - 500	126	55,326	819	1,250,715	18,005	750,702	439.1	3,261	24,713	25.9	52,065	413.2	400 - 500
500 - 600	84	45,039	693	1,195,389	18,089	795,741	536.2	2,388	21,452	28.4	42,651	507.8	500 - 600
600 - 700	61	38,856	609	1,150,350	18,150	834,597	637.0	1,733	19,064	28.4	37,123	608.6	600 - 700
700 - 750	30	21,386	548	1,111,494	18,180	855,983	712.9	909	17,331	30.3	20,477	682.6	700 - 750
750 - 800	25	19,087	518	1,090,108	18,205	875,070	763.5	747	16,422	29.9	18,340	733.6	750 - 800
800 - 850	18	14,641	493	1,071,021	18,223	889,711	813.4	568	15,675	31.6	14,073	781.8	800 - 850
850 - 900	22	19,051	475	1,056,380	18,245	908,762	866.0	632	15,107	28.7	18,419	837.2	850 - 900
900 - 950	36	32,985	453	1,037,329	18,281	941,747	916.3	1,063	14,475	29.5	31,922	886.7	900 - 950
950 - 1000	19	18,387	417	1,004,344	18,300	960,134	967.7	633	13,412	33.3	17,754	934.4	950 - 1000
1000 - 1500	121	145,646	398	985,957	18,421	1,105,780	1,203.7	3,990	12,779	33.0	141,656	1,170.7	1000 - 1500
1500 - 2000	63	108,596	277	840,311	18,484	1,214,376	1,723.7	2,220	8,789	35.2	106,376	1,688.5	1500 - 2000
2000 & UP	214	731,715	214	731,715	18,698	1,946,091	3,419.2	6,569	6,569	30.7	725,146	3,388.5	2000 & UP

* BASED UPON ONE BARREL FOR EACH 200 FEET OF DEPTH

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Two wells of General Petroleum Company being drilled adjacent to the Ford Motor plant at Long Beach, California, with iron pants.

allotment based upon depth, of five barrels for the first 1,000 ft., six barrels for the second 1,000 ft., seven barrels for the third 1,000 ft., etc. There is then assigned a top allotment of 250 bbl. to wells having a potential of 855 bbl. daily which are 10,000 ft. in depth, 1,145 bbl. daily for wells which are 6,000 ft. in depth and 1,315 bbl. daily for wells which are 3,000 ft. in depth.

Division of State Quota
June, 1939

	Wells	Potential	Minimum Allotment	Remaining Allotment	Total Allotment
Marginal wells	10,038	88,517	88,517	910	88,517
Intermediate wells	8,283	907,413	192,229	205,205	397,434
Top wells.....	406	1,105,188	22,737	79,513	102,250
Total.....	18,747	2,101,118	303,483	284,718	588,201

To all of the other wells intermediate between the marginal wells incapable of producing more than their minimum allotment and the top wells, there is assigned an additional allotment equivalent to a 0.76 power factor of the remaining potential after deducting the minimum allotment from the potential of the well. All of this is expressed upon the accompanying simple tabulation and any operator can upon inspection determine the allotment accruing to any well. This fact alone takes away a great deal of the mystery of the calculation of curtailment. It is more understandable to the average producer unschooled in higher mathematics and in addition is thought to be the most equitable form of programming curtailment yet devised.

It is evident that out of the state quota for June, 1939, of 588,201 bbl. daily, that 88,517 bbl. daily is assigned 10,058 wells in the form of minimum allotment and that all of these wells can produce no more than their minimum allotment and hence comprise the marginal or stripper wells. The top wells, 406 in number, account for 102,250 bbl. daily and the minimum allotment of that group alone is 22,737 bbl. daily. The 8,283 intermediate wells get the bulk of the state quota, both in minimum allotment and total allotment. It is interesting to note that the minimum allotment alone (allotment based upon depth) accounts for 52 percent of the entire state quota and that from potential alone is derived the remaining 48 per cent. It is thought that a forward step in getting away from potentials has been taken in assigning such a large part of the state quota upon depth of wells. Also, through the use of the top allotment, approximately one-half of the total potential of the state has been discarded from calculations solely because of its size or excess. When the importance of the potential is diminished in allocation procedure, competition among neighboring producers is lessened.

Operating experience with this formula has shown the great acceptance with which operators view it by reduced state production. Where previously there had been outright refusal by many operators to curtail to quotas because their quotas were less than the quotas for similar wells in other fields, those same operators curtailed to their new quota when they found that the same quota had been issued to the wells of producers in other fields. It is too early to predict that this formula will be the last word in the mathematics of California curtailment, but it is far closer to an ideal than anything previously used.

During the study by the central committee, prior to the adoption of the uniform formula, a compilation was made of the wells of the state according to potential grouping and depths, and the resultant table showing potential grouping of wells according to size is included herewith and has upon it the salient features useful in endeavoring to create

a form of graduated equitable curtailment. This table possibly has more information pertaining to the wells in the state of California than has ever been compiled on any similar sized sheet of paper and a careful perusal by the reader will bring a great many things to light:

EFFECTS OF CURTAILMENT

Curtailment has been in effect in California on a state-wide basis for 9½ years. It started at the beginning of 1930 following a period of tremendous overproduction when 186,000,000 bbl. of oil were in storage. From a broad viewpoint, voluntary curtailment has been successful in that stocks were reduced consistently for 5½ years until the middle of 1935 when 120,000,000 bbl. were in storage. There have been only two periods, 1935 and 1938, during which production got out of hand and stocks were built up to a high point. During those 9½ years, prices for crude have been reduced only three times, in the middle of 1931, 1933 and the end of 1935. Yet each of those three price reductions were caused by gasoline wars which preceded the first price cut by several months. Curtailment has been without hard and fast rules, sufficiently elastic to fit all situations. Voluntary curtailment has not been the most equitable form of curtailment because it always involved sacrifices on the part of the complying group to cover up the excess production of those who refused to cooperate. In the group of recalcitrants who will not play ball may be found promoters entering the oil business on an unsound basis with excessive obligations to supply companies and other creditors, the obstreperous landowner who will not consent to curtailed operations on his lease and the disgruntled operator who feels he is not getting a square deal for one reason or another. Last but not least are newcomers in the business who cannot see their way to curtail until they have gotten back their capital. Organized labor has cooperated well in proration efforts knowing that in the long run a constantly stabilized industry is better than one that is intermittently in chaos.

The organization and management of voluntary curtailment may be briefly summarized as follows:

1. Curtailment is entirely in the hands of the oil producers.
2. Elections are held annually and a central committee of California oil producers is elected.
3. The central committee establishes the state quota and method of division to the wells of the state.
4. The oil umpire is the administrative officer of the program and keeps all statistics.
5. Curtailment of the well involves a minimum allotment or an exemption from curtailment, depending on the depth of the well. A top allotment of 250 bbl. daily is the maximum any well can get, regardless of size. Between the depth and top allotment there is a graduated scale which applies increasingly greater curtailment as wells are larger.
6. Acreage, reserves, sand thickness, gravity, quality of oil, price of oil, water encroachment, financial troubles or ownership are not given any weight in calculating allotments, the only two factors being depth and potential of the well.
7. There is no method of enforcement, although purchasing companies adhering to the curtailment program, endeavor to get producers to comply. The curtailment program functions upon a cooperative, recommended basis of production. Once the oil is in the tank no steps are taken as to whom the producer sells his oil, how much he sells or at what price. In other words the whole curtailment program is based upon an extraction rate and does not interfere with trade or commerce thereafter.

Even in town lot development, California drilling practice allows for fairly wide spacing — the Montebello field.
Photo by Cy La Tour & Son

WORLD OIL P

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified

U. S. BARRELS

	June 1938	July 1938	August 1938	Sept. 1938	Oct. 1938	Nov. 1938	Dec. 1938	Jan. 1939	Feb. 1939	Mar. 1939	Apr. 1939	Preliminary Figures May 1939
United States	94,277,000	102,898,000	106,165,000	98,661,000	101,830,000	98,567,000	102,287,000	102,490,000	93,475,000	106,768,000	105,510,000	**108,500,000**
Soviet Union[1]	18,540,000	18,200,000	17,600,000	17,500,000	17,400,000	17,250,000	17,050,000	17,000,000	17,500,000	18,000,000	18,100,000	**18,500,000**
Venezuela	16,302,150	14,912,555	16,616,673	16,271,096	17,352,171	16,356,204	16,744,163	16,489,347	14,899,459	15,646,415	16,980,646	**16,600,000**
Iran [5]	5,792,228	5,338,990	5,861,366	5,676,998	7,136,578	7,221,080	6,624,726	6,408,776	4,982,000	6,999,058	6,900,000[1]	**7,000,000**
Netherlands India: Sumatra	2,893,856	2,814,237	2,901,321	2,917,167	3,049,196	3,015,432	3,177,589	3,129,007	2,969,950	3,393,286	3,400,503	**3,450,000**
Borneo	1,013,163	1,061,980	970,690	1,069,872	1,123,102	1,090,009	1,114,535	1,115,570	1,000,937	1,134,647	1,123,474	**1,137,000**
Java[9]	616,845	585,086	524,384	482,417	523,623	515,160	529,658	535,297	503,441	550,097	509,355	**535,000**
Ceram	49,870	54,035	54,825	50,355	50,444	45,750	45,773	49,200	55,219	67,442	82,914	**70,000**
Roumania	4,015,000	4,115,000	4,075,736	3,915,029	4,028,750	3,847,324	3,969,300	3,934,338	3,638,020	3,973,053	3,759,111	**3,850,000**
Mexico [18]	2,564,886	2,864,277	3,247,904	3,416,583	3,313,182	3,098,725	3,245,558	2,470,000[1]	1,960,000[1]	3,118,021	3,140,720	**2,945,000**
Iraq	2,653,579	2,806,903	2,829,528	2,621,547	2,431,949	2,420,143	2,290,777	2,414,878	1,955,122	2,699,272	2,608,216	**2,620,000**
Colombia	1,826,136	1,826,848	1,870,013	1,797,158	1,891,825	1,863,838	1,908,879	1,710,565	1,633,621	1,818,765	1,826,928	**1,710,000**
Trinidad	1,431,476	1,500,171	1,505,959	1,514,893	1,594,480	1,503,489	1,664,322	1,652,412	1,499,197	1,630,789	1,569,298	**1,640,000**
Argentina [1]	1,346,000	1,349,000	1,360,000	1,358,000	1,360,000	1,358,000	2,028,000	2,000,000	1,300,000	1,800,000	1,740,000	**1,795,000**
Peru[2]	1,303,536	1,335,623	1,328,143	1,280,691	1,331,111	1,303,990	1,321,883	1,251,162	1,103,878	1,210,288	1,151,193	**1,250,000**
Bahrein[6]	661,602	699,176	713,149	714,349	708,962	613,281	623,907	647,988	610,766	658,822	629,336	**626,009**
Burma [7]	679,368	654,108	637,880	623,630	604,885	591,029	651,495	650,000[1]	500,000[1]	640,000[1]	635,000[1]	**640,000**
Canada[3]	537,654	693,332	817,706	886,111	685,088	445,514	489,303	531,564	356,218	384,461	558,779	**550,000**
Brunei [8]	425,184	453,393	448,219	478,080	477,459	484,207	510,500	506,467	453,571	492,374	466,328	**486,815**
Great Germany: Old Reich[14]	326,842	346,435	342,484	328,098	331,792	307,433	313,206	332,592	330,584	395,181	373,126	**360,000**
Ostmark[15]	30,000[1]	31,062	29,453	26,772	43,697	29,000[1]	34,259	33,609	46,666	43,293	54,375	**43,000**
Slovakia	10,159	9,333	11,015	10,933	13,747	10,502	9,879	10,546	9,000[1]	10,000[1]	9,500[1]	**10,000**
Poland	315,381	314,000[1]	328,115	321,134	330,412	318,000[1]	316,702	325,293	298,259	333,618	318,000[1]	**330,000**
Japan [16]	216,707	216,707	217,525	170,597	220,451	224,255	173,737	224,885	218,594	222,368	218,594	**220,000**
British India[11]	192,656	241,191	225,897	217,058	210,348	197,809	217,528	195 000[1]	132,000[1]	230,000[1]	215,000[1]	**230,000**
Ecuador	188,712	192,360	193,634	189,037	192,702	185,669	192,882	195,556	171,634	181,938	175,896	**193,353**
Saudi Arabia	3,477	3,550	3,459	40,556	136,947	152,632	139,038	155,605	170,865	215,270	234,742	**281,325**
Sarawak [12]	132,240	132,007	107,102	123,476	223,165	115,952	118,512	116,030	105,714	115,980	110,982	**102,660**
Egypt[13]	84,998	83,412	143,978	157,533	208,377	211,841	221,156	308,946	301,102	330,445	328,376	**369,972**
Italian Empire: Albania [10]	72,300	46,049	4,998	68,655	Nil	Nil	6,220	99,206	67,914	125,440	83,000[1]	**89,000**
Italy	8,646	9,378	9,057	8,267	8,622	8,533	7,937	7,511	8,090	8,324	8,100[1]	**8,200**
France	43,189	43,574	43,000[1]	41,104	42,296	40,797	48,000[1]	42,000[1]	40,000[1]	42,000[1]	41,000[1]	**42,000**
Hungary	26,018	25,888	30,900[1]	38,240	49,800[1]	43,303	47,671	49,199	49,578	67,261	67,000[1]	**70,000**
Bolivia [1]	8,790	9,500	9,200	8,500	8,800	8,500	9,000	8,800	7,000	8,700	8,500	**8,700**
Other Countries [17]	5,800	6,000	6,000	50,000	48,000	50,000	48,000	50,000	35,000	50,000	48,000	**50,000**
WORLD TOTAL	158,595,448	165,873,160	171,234,333	163,034,936	168,952,001	163,494,401	168,191,035	167,141,349	152,388,399	173,364,608	172,985,392	**176,313,034**

[1] Estimated.
[2] Includes natural gasoline production.
[3] International Petroleum Company and Lobitos Oilfields, Ltd. figures combined.
[4] Russian Saghalin included with U.S.S.R.
[5] Anglo-Iranian Oil Company, Ltd., figures revised—fuel oil returned to the ground has been deducted.
[6] Bahrein Petroleum Company, Ltd., figures.
[7] Does not include Assam or Punjab, which are listed together under British India.
[8] British Malayan Petroleum Company, Ltd., figures.
[9] Includes Madura.

Official Crude Oil Production Figures for 1932 to 1938 (Revised) in Barrels

	Daily Av. Jan.-May 1939	Daily Av. Jan.-May 1938	Jan.-May 1939	Jan.-May 1938	Daily Av. 1938	Total 1938	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**3,422,139**	3,368,205	**516,743,000**	508,599,000	3,323,984	1,213,254,000	1,279,160,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Soviet Union	**590,066**	547,364	**89,100,000**	82,652,000	564,909	206,192,000	201,856,661‡	199,635,921	184,008,033	175,635,783	155,596,429	155,927,997
Venezuela	**533,880**	489,166	**80,615,867**	73,864,040	475,360	173,506,497	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940	115,615,782
Iran	**213,840**	229,615	**32,289,834**	34,671,885	214,577	78,320,840	78,109,001	62,977,950	57,520,488	57,902,092	54,440,075	49,516,697
Netherland India: Sumatra	**108,230**	92,425	**16,342,746**	13,956,182	94,625	34,538,128	33,451,511	30,469,428	28,004,595	26,336,011	22,345,172	18,570,928
Borneo	**36,501**	35,557	**5,511,628**	5,369,026	35,102	12,812,383	12,960,072	13,068,910	13,529,185	14,335,543	15,003,175	15,228,615
Java	**17,438**	21,099	**2,633,190**	3,185,942	19,056	6,955,283	7,152,931	3,618,293	3,462,440	3,778,920	3,600,816	3,837,142
Ceram	**2,151**	1,703	**324,775**	257,174	1,665	607,622	537,436	375,823	311,872	273,698	285,335	309,957
Roumania	**126,851**	134,382	**19,154,522**	20,291,692	132,508	48,366,000	52,395,725	63,532,846	61,270,072	61,849,306	53,919,708	53,651,978
Mexico	**90,286**	110,959	**13,633,141**	16,754,709	105,495	38,505,824	46,455,687‡	41,027,915	40,240,563	38,171,946	34,000,830	32,805,496
Iraq	**81,440**	84,102	**12,297,488**	12,699,428	88,778	32,404,000	30,603,660‡	29,913,150	27,410,983	7,639,849	1,094,915	871,840
Columbia	**57,615**	56,933	**8,699,879**	8,596,891	59,127	21,581,588	20,297,543‡	18,756,110	17,597,655	17,337,900	13,156,126	16,415,214
Trinidad	**52,925**	46,432	**7,991,696**	7,011,366	48,592	17,736,176	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353	10,126,121
Argentina	**57,186**	44,888	**8,635,000**	6,778,000	46,784	17,076,223	16,354,717	15,457,960	14,297,025	14,021,901	13,690,556	13,138,747
Peru	**39,513**	37,770	**5,966,521**	5,703,302	43,584	15,908,279	17,459,112	17,593,069	17,056,555	16,314,381	13,257,318	9,899,265
Bahrein	**21,013**	24,268	**3,172,921**	3,664,492	22,734	8,297,998	7,762,264	4,644,635	1,264,807	285,072	31,377	902
Burma	**20,298**	20,197	**3,065,000**	3,049,721	20,549	7,499,498	7,847,553	7,587,718	7,181,113	7,278,859	7,114,311	7,073,437
Canada	**15,769**	15,774	**2,381,022**	2,381,769	19,004	6,936,479	2,995,025	1,507,931	1,447,204	1,410,895	1,145,333	1,044,412
Brunei	**15,931**	13,975	**2,405,555**	2,110,172	14,759	5,387,214	4,397,038	3,296,938	3,302,905	2,705,350	2,035,656	1,200,026
Great Germany: Old Reich	**11,864**	10,290	**1,791,483**	1,553,754	10,548	3,850,044	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602	1,594,807
Ostmark	**1,463**	966	**220,943**	145,795	1,014	370,038	221,266	50,092	44,347	27,965	5,765	804
Slovakia	**325**	367	**49,046**	55,356	359	130,867	122,790	126,603	136,580	177,797	121,695	126,603
Poland	**10,630**	10,463	**1,605,170**	1,579,808	10,489	3,828,438	3,799,862	3,869,575	3,901,881	4,011,336	4,174,079	4,219,634
Japan	**7,314**	5,770	**1,104,441**	871,205	6,880	2,511,184	2,487,841	2,403,072	2,294,878	1,872,837	1,504,412	1,683,439
British India	**6,636**	6,107	**1,002,000**	922,068	6,384	2,330,209	2,161,653	1,978,329	2,037,810	1,921,863	1,628,803	1,743,878
Ecuador	**6,082**	6,108	**918,377**	922,282	6,184	2,257,278	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902	1,597,641
Saudi Arabia	**7,006**	103	**1,057,807**	15,476	1,356	495,135	64,968	19,777	Nil	Nil	Nil	Nil
Sarawak	**3,652**	4,453	**551,366**	672,428	4,452	1,624,882	1,655,565	1,547,882	1,776,593	1,942,591	2,206,815	2,329,733
Egypt	**10,853**	2,980	**1,638,841**	449,936	4,277	1,561,231	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535	1,071,976
Italian Empire: Albania	**3,077**	1,374	**464,560**	207,400	1,199	437,597	380,292	219,693	41,218	17,500	11,437	9,218
Italy	**266**	296	**40,225**	45,651	291	106,083	112,700	129,653	128,615	162,449	213,534	242,563
France	**1,371**	1,440	**207,000**	217,373	1,414	516,240	507,057	534,063	529,664	700,000	786,366	755,146
Hungary	**2,007**	481	**303,038**	72,647	906	330,829	13,910	100	Nil	Nil	Nil	Nil
Bolivia	**276**	294	**41,700**	44,330	292	106,620	123,123	104,746	163,295	157,875	111,973	41,907
Other Countries	**1,543**	194	**233,000**	29,200	665	243,000	70,000	37,100	32,3000	64,000	54,100	73,300
WORLD TOTAL	**3,577,437**	5,426,500	**842,192,782**	819,401,500	5,387,905	1,966,585,707	2,041,168,442	1,797,891,143	1,652,023,331	1,516,760,036	1,438,797,443	1,305,574,242

‡ Preliminary

PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries

METRIC TONS

	June 1938	July 1938	Aug. 1938	Sept. 1938	Oct. 1938	Nov. 1938	Dec. 1938	Jan. 1939	Feb. 1939	Mar. 1939	Apr. 1939	Preliminary Figures May 1939
United States	12,762,583	13,939,606	14,507,243	13,189,481	13,785,028	13,343,306	13,846,893	13,874,374	12,653,243	14,445,677	14,275,470	**14,680,000**
Soviet Union[4]	2,543,000	2,497,000	2,414,000	2,401,000	2,387,000	2,366,000	2,339,000	2,332,000	2,400,000	2,469,000	2,480,000	**2,536,000**
Venezuela	2,409,066	2,205,195	2,455,545	2,404,477	2,564,234	2,417,054	2,474,385	2,438,207	2,201,782	2,323,150	2,521,254	**2,450,000**
Iran [5]	766,064	706,120	775,208	750,824	943,864	955,040	876,168	850,212	661,050	927,608	918,000[1]	**920,000**
Netherland India: Sumatra	388,437	377,750	389,439	391,566	409,288	404,756	426,522	420,001	398,651	434,424	435,476	**442,000**
Borneo	135,995	142,549	130,294	143,607	150,752	146,310	149,602	149,741	134,354	146,543	142,552	**144,000**
Java[9]	82,798	78,535	70,387	64,754	70,285	515,160	71,095	71,852	67,576	70,426	65,210	**71,000**
Ceram	6,694	7,253	7,359	6,759	6,771	6,141	6,144	6,604	7,412	8,634	10,615	**9,000**
Roumania	548,139	561,775	556,415	534,475	550,000	525,232	541,684	537,111	496,658	538,719	509,710	**525,000**
Mexico[10]	380,773	425,219	482,171	507,212	491,862	460,025	481,823	367,000[1]	291,000[1]	457,859	461,104	**432,000**
Iraq	355,803	376,415	379,395	351,508	326,086	324,503	312,734	323,797	262,151	360,817	348,648	**351,000**
Colombia	254,514	254,669	260,629	250,475	263,669	259,768	266,046	238,406	229,371	253,663	254,802	**238,000**
Trinidad	201,446	211,113	211,928	213,185	224,385	211,580	234,214	232,537	210,413	229,306	220,717	**231,000**
Argentina [1]	191,900	192,200	193,800	193,500	194,000	193,500	288,930	285,000	184,000	190,000[1]	188,000[1]	**195,000**
Peru[2]	172,745	168,725	176,006	167,718	177,893	172,805	175,667	166,281	146,286	159,774	151,973	**165,000**
Bahrein[6]	90,435	95,428	97,279	97,479	96,660	83,585	85,009	88,264	83,180	89,811	85,920	**85,353**
Burma[7]	93,797	90,309	88,068	86,101	83,548	81,634	89,985	89,100[1]	70,000[1]	90,000[1]	87,800[1]	**90,000**
Canada [8]	67,934	87,586	103,298	111,686	86,545	56,280	61,812	67,151	45,000	57,640	71,109	**70,000**
Brunei[9]	55,552	59,464	58,772	62,688	62,607	63,491	66,939	66,410	59,474	65,749	62,271	**65,007**
Great Germany: Old Reich[14]	47,075	49,897	45,007	47,256	47,788	45,865	45,111	47,562	47,614	56,654	53,357	**50,500**
Ostmark [15]	5,800[1]	4,634	4,394	3,994	6,519	5,600[1]	5,111	5,014	6,962	6,454	8,106	**6,500**
Slovakia	1,484	1,521	1,609	1,597	2,008	1,534	1,443	1,545	1,500[1]	1,500[1]	1,600[1]	**1,500**
Poland	41,607	41,000[1]	43,287	42,366	43,590	42,000[1]	42,688	43,819	40,202	44,968	41,000[1]	**44,000**
Japan[10]	30,839	30,839	30,955	24,277	31,376	31,913	24,724	32,003	31,094	31,631	31,095	**31,000**
British India[11]	26,599	33,300	31,174	29,968	29,054	27,322	30,045	27,000[1]	18,000[1]	33,000[1]	30,000[1]	**33,000**
Ecuador	26,743	27,262	27,412	26,791	27,310	26,314	27,336	27,715	24,325	23,986	23,190	**25,491**
Saudi Arabia	451	460	453	5,498	18,570	20,697	18,590	21,100	23,169	29,190	31,821	**38,148**
Sarawak [12]	17,340	17,309	13,913	16,191	16,150	15,204	15,540	15,214	13,862	15,838	14,197	**14,401**
Egypt[13]	12,151	11,924	20,583	22 521	29 789	30,285	31,617	44,390	43,045	47,193	46,897	**52,838**
Italian Empire: Albania [16]	10,790	6,873	746	10,247	Nil	Nil	41,674	14,869	10,179	18,801	12,000[1]	**13,000**
Italy	1,074	1,164	1,125	1,027	1,071	1,060	986	933	1,005	1,034	1,000[1]	**1,000**
France	6,048	6,102	6,000[1]	5,756	5,923	5,713	6,000[1]	5,900[1]	5,500[1]	6,000[1]	5,700[1]	**6,000**
Hungary	3,366	3,349	4,000[1]	4,947	6,400[1]	5,602	6,167	6,619	6,670	9,049	9,000[1]	**9,500**
Bolivia [1]	1,100	1,200	1,160	1,000	1,100	1,000	1,130	1,100	900	1,000	1,000	**1,000**
Other Countries[17]	830	850	850	7,000	6,700	7,000	6,700	7,000	6,000	7,000	6,700	**7,000**
WORLD TOTAL	21,770,972	22,714,595	23,589,804	22,178,931	23,353,817	22,853,279	23,099,714	22,905,831	20,881,628	23,652,098	23,607,294	**24,034,238**

[10] Japanese Saghalin, Taiwan (Formosa) and Hokkaido included with Japan.
[11] Excluding Burma.
[12] Sarawak Oilfields, Ltd., figures.
[13] Anglo-Egyptian Oilfields Ltd. figures.
[14] Prussia, Thuringia and Baden.
[15] Formerly known as Austria
[16] Italian imports of Albanian crude oil.
[17] Nominal figure representing proportion to world total represented by: Morocco, Cuba, New Zealand, Barbados, Greece, Algeria, Yugoslavia, Australia, Great Britain, Kuwait and China.
[18] Official Figures-Petroleos Mexicanos.

Official Crude Oil Production Figures For 1932 to 1938 (Revised) in Metric Tons

	Daily Av. Jan.-May 1939	Daily Av. Jan.-May 1938	Jan.-May 1939	Jan.-May 1938	Daily Av. 1938	Total 1938	Total 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	**463,104**	449,368	**69,928,764**	67,854,575	447,202	163,228,715	172,822,797	148,707,864	134,912,143	122,913,903	122,601,191	106,289,292
Soviet Union	**80,907**	78,887	**12,217,000**	11,912,000	79,066	28,859,000	27,867,025‡	27,384,900	25,241,100	24,092,700	21,330,100	21,389,300
Venezuela	**79,035**	72,068	**11,934,393**	10,915,330	76,288	27,845,286	27,733,926	22,945,299	21,990,373	20,112,115	17,293,193	17,085,334
Iran	**28,336**	30,368	**4,276,870**	4,585,607	28,379	10,358,495	10,330,480	8,329,289	7,607,500	7,657,970	7,200,093	6,548,941
Netherland India: Sumatra	**14,109**	12,416	**2,130,552**	1,874,792	12,775	4,662,836	4,490,137	4,114,710	3,759,006	3,535,035	2,999,352	2,492,742
Borneo	**4,749**	4,773	**717,190**	720,675	4,712	1,719,783	1,739,607	1,773,545	1,815,998	1,924,234	2,013,849	2,043,707
Java	**2,291**	2,831	**346,064**	427,509	2,559	933,595	960,125	499,097	464,757	510,320	483,331	515,187
Ceram	**280**	229	**42,265**	34,520	224	81,560	72,139	50,446	41,862	36,738	38,300	41,605
Roumania	**17,266**	18,342	**2,607,198**	2,769,623	18,090	6,603,000	7,153,000	8,704,000	8,394,000	8,473,355	7,387,000	7,350,321
Mexico	**13,304**	16,742	**2,008,963**	2,487,339	15,662	5,716,423	6,896,657‡	6,090,842	5,973,955	5,666,857	5,049,109	4,870,175
Iraq	**10,903**	10,807	**1,646,413**	1,631,911	11,904	4,345,000	4,126,185‡	4,079,066	3,724,231	1,048,108	147,943	118,887
Colombia	**8,041**	8,406	**1,214,242**	1,269,288	8,241	3,007,935	2,844,251‡	2,614,092	2,452,635	2,416,432	1,833,606	2,287,835
Trinidad	**7,443**	6,550	**1,123,973**	988,102	6,748	2,462,943	2,181,676	1,862,796	1,642,446	1,533,122	1,345,532	1,425,009
Argentina	**6,900**	6,411	**1,042,000**	967,000	6,665	2,432,857	2,330,063	2,202,304	2,036,903	1,997,706	1,950,499	1,871,882
Peru	**5,227**	5,883	**789,314**	888,326	5,753	2,099,885	2,313,691	2,331,454	2,260,903	2,161,990	1,756,867	1,311,856
Bahrein	**2,864**	3,210	**432,528**	484,649	3,098	1,130,734	1,058,557	635,555	173,072	39,008	4,293	123
Burma	**2,827**	2,822	**426,900**	426,196	2,849	1,039,960	1,083,391	1,047,593	991,456	1,004,951	982,233	976,589
Canada	**2,059**	1,993	**310,900**	300,875	2,400	876,016	378,430	190,495	182,820	178,233	144,686	131,937
Brunei	**2,112**	1,839	**318,911**	277,610	1,937	707,123	576,545	470,991	471,842	386,478	290,808	171,432
Great Germany: Old Reich	**1,693**	1,484	**255,687**	224,075	1,513	552,074	453,451	444,600	427,400	317,500	238,600	229,700
Ostmark	**218**	182	**33,036**	27,416	174	63,468	33,010	7,473	6,616	4,172	860	120
Slovakia	**50**	54	**7,645**	8,086	52	19,282	17,936	18,665	19,946	25,971	17,776	18,493
Poland	**1,417**	1,380	**213,989**	208,418	1,383	504,678	501,301	510,630	614,760	529,200	550,670	556,680
Japan	**1,038**	1,003	**156,823**	151,405	976	356,328	341,040	341,976	326,580	266,520	212,667	239,567
British India	**933**	842	**141,000**	127,205	882	322,125	298,450	273,137	281,072	265,341	224,879	240,767
Ecuador	**825**	862	**124,707**	130,185	876	319,877	306,396	275,293	245,434	231,947	229,578	226,423
Saudi Arabia	**950**	13	**143,428**	1,964	183	66,683	8,070	2,447	Nil	Nil	Nil	Nil
Sarawak	**486**	520	**73,512**	88,479	548	200,126	217,085	221,126	253,799	277,513	315,259	332,819
Egypt	**1,552**	425	**234,363**	64,188	611	223,058	166,298	177,491	176,436	214,671	232,437	265,055
Italian Empire: Albania	**456**	201	**68,849**	30,310	179	65,313	56,760	32,760	6,152	2,500	1,707	1,375
Italy	**33**	38	**4,972**	5,671	36	13,178	14,000	16,106	15,977	20,180	26,526	27,046
France	**192**	201	**29,100**	30,300	198	72,106	71,008	74,788	74,172	98,025	110,120	105,758
Hungary	**270**	64	**40,838**	9,606	120	42,798	13,910	13	Nil	Nil	Nil	Nil
Bolivia	**33**	37	**5,000**	5,572	36	13,262	15,487	13,197	20,540	19,858	14,085	5,284
Other Countries	**233**	27	**33,700**	4,150	93	34,080	10,000	5,300	4,600	9,100	7,700	10,500
WORLD TOTAL	**762,126**	741,278	**115,081,089**	111,932,957	742,412	270,979,582	279,495,814	240,539,340	226,410,486	207,970,753	197,024,849	179,181,741

Wilson Cross, riding Royal Flush

Right—L. J. van Dyjk, equipment engineer for Royal Dutch-Shell at Maracaibo, who arrived at The Hague early in June with his wife and three sons, just before taking leave of E. S. Martin in New York.

Foreign Oil Legion

CAPTAIN TORKILD RIEBER, chairman of the board of The Texas Corporation, left New York for Marseilles from Port Washington airport aboard the flying boat, DIXIE CLIPPER, on the first Atlantic crossing made with paying passengers. Accompanying him were COL. WM. J. DONOVAN, attorney of New York and Buffalo, and ROGER LAPHAM, previously of American-Hawaiian Steamship Company. Capt. Rieber's interest in ocean transportation goes back to the days when he was master of one of the first tankers to load oil from the Spindletop field in Texas. With Mr. Lapham, he made the maiden crossing on the ill-fated airship, HINDENBURG, and was the third person to apply for trans-Atlantic passage on heavier-than-air craft (the first having been the late Will Rogers).

Capt. Rieber, Col. Donovan and Mr. Lapham are travelling together on a combined business and pleasure trip, and are to visit Paris, The Hague, Bruxelles, London, Berlin and the major cities of Denmark and Sweden. They will return to the United States about the middle of July.

B. I. Beaumont

WILSON CROSS, former chairman of Vacuum Oil Company, Ltd., London, does not appear to be getting much rest since he retired and made his home in Hollywood, California, which he regards as one of the world's most beautiful places. Social activities now keep him as busy as the problems of marketing lubricating oil formerly did in London. Drafted as president of the Riviera Country Club Horse Show, held in Hollywood May 27th–30th, he did a splendid job of organizing, with the result that the show was a great success. Mr. Cross's favorite horse, the 14-year-old Royal Flush, was entered and was awarded ribbons, while his Easy Ace also was a contender. Mr. Cross, however, has not forsaken London, where he lived for about 30 years, and has made several visits accompanied by Mrs. Cross—not to forget Royal Flush—since his retirement.

B. I. BEAUMONT, formerly drilling superintendent for Trinidad Leaseholds Ltd., is now with Continental Emsco at FRED CONVERS' office at Radio City, New York.

WM. A. SLATER, general manager of Gulf Refineries, has been elected vice-president of Gulf Oil Corporation and Gulf Refining Company. Mr. Slater is a native of Warren, Pennsylvania, and a graduate of Pennsylvania State College, class of 1907. He joined the Gulf organization in October of the same year as a chemist in the testing laboratory of the Port Arthur, Texas refinery. He was appointed, in 1929, to the position of general superintendent of Gulf refineries in Texas. He served in this capacity for six years until he was transferred to Pittsburgh as general manager of all Gulf refineries. THOMAS J. SULLIVAN, who joined Gulf in 1921 as head of the acid department at Port Arthur and has been assistant general manager of refineries since February of this year, has been appointed to succeed Mr. Slater as general manager of Gulf refineries.

REALIZING that a community interest exists between men who have traveled abroad in the interest of oil equipment manufacturers a group of such men got together in California several months ago and started an association to provide and continue social contacts between them. Details of organization were thrashed out and the name "Nomads" selected. Believing that the association should be national in scope, the group decided to make their organization a Los Angeles Chapter and invite others to form similar chapters in their localities. Such chapters are being formed in Houston and Tulsa.

The name Nomads is taken from the initials of the full name, National Oil Equipment Manufacturers And Delegates Society. Its objects are strictly social, fraternal and educational and its regular meetings will consist of monthly dinners at which the members can renew acquaintance and be entertained by programs arranged by the entertainment committee.

Active membership is limited to men who have actually visited other countries in the interest of oil equipment manufacturers. Associate members are men who devote a substantial portion of their time to oil equipment export business. From time to time honorary members will be elected from men in foreign service for oil companies

Officers duly elected by the Los Angeles Chapter upon completion of the organization were: E. L. Decker, Martin-Decker Corp., president; F. C. Ripley, Emsco Derrick & Equipment Co., vice-president; W. F. Bettis, M. O. Johnston Oil Field Service Corp., secretary-treasurer; Earl Rees, Fluid Packed Pump Co., asst. secretary-treasurer; Henry Pullman, Baker Oil Tools, Inc., sergeant-at-arms; and E. B. Fowks, Emsco Derrick & Equipment Co., asst. sergeant-at-arms.

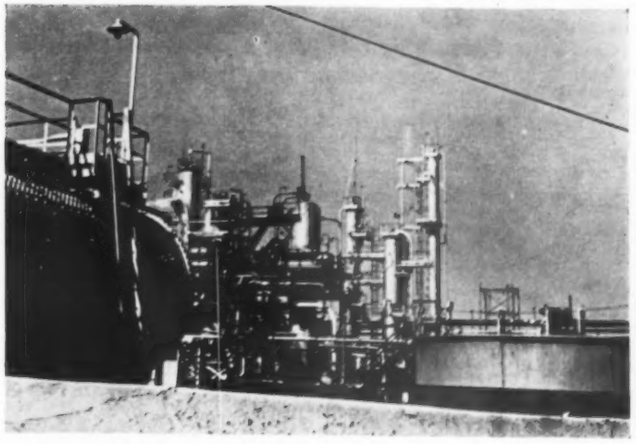
International Reports

J. E. Brantly, president of Drilling and Exploration Company, Inc., of Los Angeles, California, has spent the past several weeks in Rio de Janeiro, during which period he has entered into an agreement with Conselho Nacional do Petroleo (the department in the Brazilian Government having to do with the development of the petroleum resources of the nation) for the supervision of the exploratory and development work to be done by the Conselho, beginning in the immediate future.

Three strings of rotary drilling tools have been purchased by the Brazilian Government, two of which will be used in the State of Bahia and the third in the State of Alagoas. Several well locations in the State of Bahia will be in areas very close to the Bay, and those in Alagoas will be only a short distance from deep water harbors. The first shipment of equipment is expected to arrive in Brazil in August, and it is contemplated that actual drilling will commence during the month of September. During the month following, all three rigs are expected to be in operation.

The Government recently completed a small well near the city of São Salvador, which is the capital of the State of Bahia. Additional wells will be drilled nearby, and others in geophysical structures on the west side of the Bay.

The Government plans an intensive campaign of exploration, covering all prospective areas in the country. Drilling and Exploration Company, Inc., will supervise and direct the entire operations. Engineers and drillers will be sent down from the Mid-Continent and California fields for the purpose, while other oilfield workers will be selected from among the Brazilians. It is the intention of Drilling and Exploration Company, Inc., to train Brazilian engineers and technicians in the operation of rotary drilling equipment, with the end in view that the entire mechanical operations will eventually be taken over by the Brazilian personnel.

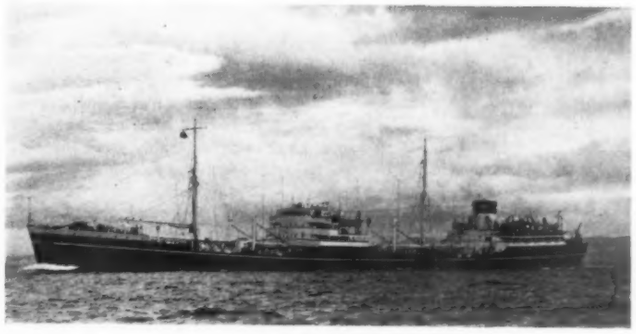


New gasoline recovery plant nearing completion at Standard Oil Company of New Jersey's Bayway refinery at Elizabeth, New Jersey.

According to an official communique of June 11th, 1939, the Minister of Public Works has been informed by members of the Corps of Mining Engineers who have charge of drilling operations in the Government oil lands of Peru, in the Department of Puno, that the R. P. 2 well, which is the second well so far drilled, has been found to contain oil with a high gas pressure at 100 bbl. daily.

The economic importance of this fact is said to be that crude oil will now be supplied to the southern districts (Cuzco and Puno) at prices comparable to those prevailing in the coastal districts. The installation of a refinery is proposed.

Drilling of new lands in the northern district of Zorritos is also reported to have met with success and the well R. T. 14 is yielding eight barrels per day.



The A. G. I. P., Italian government oil company, recently added to its fleet the new high-speed motor tanker Iridio Mantovani. It is rated at over 16 knots.

Installing a twin crank pumping unit at Anglo-American Oil Company Ltd.'s Dalkeith No. 1 well in the Midlothians, Scotland—the first oil producer of the current British drilling campaign.

Tendency for this year's British petroleum import volume to run even with last year's figures continued in May. Imports for the month of crude and all products amounted to 8,259,000 bbl., an increase of 3.3 percent over 1938. They brought the aggregate receipts for the five months to 39,299,000 bbl., or within 0.4 percent of the figure for the corresponding period of last year. Changes between the main products are considerable, nevertheless, motor spirit imports for January-May increasing by 8.5 percent, while fuel oil shipments fell 26.4 percent. Venezuela strengthened its position as the main source of crude supplies, and Netherlands West Indies as the principal supplier of motor spirit. British West Indies has greatly expanded its shipments of fuel oil, the fall in the total of this product for the five months being due to lower shipments from Netherlands West Indies.

Export headquarters have been established by The Buckeye Traction Ditcher Company at 80 Broad Street, New York City. This office will handle all export-contacts and sales.

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

GEOLOGY

A New Paleontologic Correlation Method—H. B. Stenzel and R. W. Cumley, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

The gastropod species *Turricula gabbii* (Conrad) is one of the most common fossils of the middle Eocene Claiborne group of east and central Texas. This species and its ancestors can be traced through about 500 ft. of beds. During its evolution the number of riblets on the protoconch decreases from about 188 to 85. This decrease in the number of riblets is so gradual and can be measured to such accuracy that it can be used for an exact corrulation of the beds. The results are similar to those obtained from a study of Jurassic ammonites in England.

Geology of the Basin Fields in Southeastern Illinois—Lynn K. Lee, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

All except the Flora field are associated with a general north-south anticline, which has a slight southward plunge of the axis into the deeper part of the basin. Accumulation has been, for the most part, on local closures along the axis, but some production has been obtained from noses and terraces on the flanks on the main feature.

Little is known of the pre-Mississippian structural history. The known period of major deformation was post-Mississippian pre-Pennsylvanian; however, subsequent to this there was recurrent folding.

Production is from oölitic limestone of the Ste. Genevieve formation (McClosky) except in the north Noble field, where it is from the Cypress (Weiler) sandstone, the former being in the upper part of the Lower Mississippian and the lower part of the middle Chester.

The Cypress is a widespread sandstone but locally subject to lensing into beds of sands and shales and even completely to shale. It is believed that Chester sandstone production will become more important as development extends northward. The oölitic character of the Ste. Genevieve is persistent over the area; however, porosity occurs in lenses of variable proportions laterally and vertically. Approximately ten percent of the holes drilled within the limits of production are dry because of lack of porosity in the lime; but, porosity is more persistent on the structures than in the synclines. The relation of the contact of the Ste. Genevieve to the overlying Chester is controversial; however, the data do not indicate an angular unconformity of any extent at this contact in the deeper part of the basin.

Oil Shale Deposits of Central Texas—F. B. Plummer and Bruce Grant, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

The deposits of oil shale in the Barnett formation (late Mississipian), which outcrops along the north side of the Llano Uplift in central Texas are briefly described, and maps showing their occurrence and extent are presented. The origin and character of the shale are discussed and its petroliferous content described by a graph and a table of analyses. Although the shale is fairly uniform in thickness and in lithologic character, its oil content varies considerably from place to place. The thickness and most petroliferous spots appear to be located in synclinal areas. It is concluded that this shale is a source of some of the oil produced in the deeper wells in north-central Texas and that a detailed study of the distribution of the petroliferous material in it will furnish new information concerning the characteristics of source rocks.

Relationships of Crude Oils from the Mississippi Lime and the Shoestring Sands of the Cherokee Shales in Oklahoma and Kansas—N. Wood Bass and Harold M. Smith, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March, 1939.

In the present investigation, crude oil analyses made by the Bureau of Mines Hempel method were compared by the correlation index method, recently developed by Smith. This method employs a simple index number whose derivation is based on the boiling point-specific gravity relationships of pure hydrocarbons, and whose magnitude indicates certain characteristics of a fraction distilling at definite temperature intervals. The character of an oil may then be shown graphically by plotting the indices for the entire series of distilled fractions.

The 75 oils examined in this investigation occur in four stratigraphic zones, which are, in ascending order (1) the Mississippi lime, which in a few places includes the Burgess sand that lies on the lime, (2) the lower Bartlesville sand, (3) the Bartlesville sand, and (4) the Burbank sand. The investigation showed that the four zones contain three kinds of oils. The Bartlesville and Burbank oils are of one general type but are sufficiently different from each other to make their differentiation possible. The Burbank oil is distinctly more paraffinic than the Bartlesville oil. The Mississippi lime oil in Osage County, Oklahoma, is like the Bartlesville oil, and the Mississippi lime oil in Butler County, Kansas, is like the Burbank oil. The lower Bartlesville oil is a clearly distinct type.

The facts disclosed lead to the following tentative conclusions: 1. The oils from the lower Bartlesville, Bartlesville, and Burbank sands probably were derived from marsh and near-shore sediments that were deposited during three separate stages of the Cherokee sea, during which stages the sands also were deposited. (2) The oil from the Mississippi lime in Osage County, Oklahoma, was derived from the same sediments as the oil in the Bartlesville sand; the main oil pools in the Mississippi lime in Osage County are in contact with the source sediments, but some oil has migrated southeastward several miles through the uppermost porous zone of the Mississippi lime.

GEOPHYSICS

Geomagnetic Exploration in 1938—Noel H. Stearn in GEOPHYSICS, vol. 4 (1939), No. 2, pp. 118-122.

The chief use of the geomagnetic method in geophysics appears to be in scouting work, for instance as a preliminary survey to electrical work and as directional to extensive seismographic work in the San Joaquin Valley of California. It is also employed in extensive regional surveys such as the one that is being carried on by the Missouri Geological Survey which is aimed at the problem of outlining major regional structural features. This work has given some indications that may be of interest regarding regional structure in the adjacent fields of western Illinois.

Perhaps the most active area for the local use of geomagnetics in the oil industry lies in South Texas, as a result of reports crediting the method with assisting in the discovery of the Sinton, Plymouth, Heyser, Sweden, and Hoffman Pools. As was the case last year, thought on the success of the magnetic method in South Texas is sharply divided among three groups. First, there are those who believe in magnetics, pointing to the fact that credit for the discovery of several oil pools has been partly given to magnetic surveys. Second, there are those who disbelieve, pointing to the fact that the data supporting magnetic applicability in the area are purely empirical, that no reasonable theoretical background for the interpretation of magnetic anomalies in this region has been articulated by the proponents of the method and that statistically the presence of oil pools in indirect association with magnetic anomalies could be purely fortuitous. Third, there are those who, recognizing the force of the empirical data submitted by the proponents and acknowledging the validity of the arguments advanced by the opponents, have decided to withhold judgment in the matter.

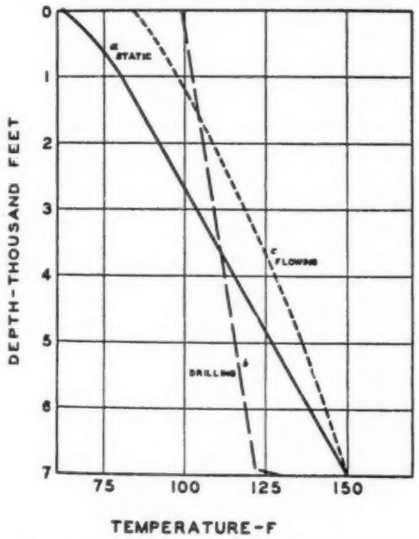
Geothermal Gradients in California Oil Wells—R. W. French, before AMERICAN PETROLEUM INSTITUTE, Pacific Coast District, Los Angeles Meeting, April, 1939.

A tabulation is given to show depths at which a temperature of 175 deg. F. is recorded; this varies

Field—	Depth (ft.)	Temp. (F.)	Remarks
Canal	8,130	210	
Elwood	3,600	158	
Mountain View	5,725	139	
Newhall Potrero	7,100	175	
Richfield Western	8,400	222	Shut in.
Rincon	2,999	111	Shut in.
Rio Bravo	10,990	165	Drlg. well.
Rio Bravo	11,400	210	Drlg. well.
Rosecrans	7,750	212	
Round Mountain	1,800	110	
Ten Section	8,150	210	
Torrance	5,150	200	
Venice	3,800	160	
Wasco	14,000[1]	256	Drlg. well.
Wasco	9,000	220	Shut in.
Wasco	9,000	226	Flowing.
Wasco	9,000	245	Flowing.
Wasco	9,000	255	Flowing.

[1] Producing from 13,134 feet.

from a minimum of 3,200 ft. in the Lompac to 7,170 ft. in the San Miguelito field, and affords a means of comparison by which hot can be distinguished from cool fields. Perhaps the most important causes of these temperature variations are differences in the heat conductivity characteristics of various rocks and the relative proximity of the basement complex. Annual average atmospheric temperature hardly appears to have any noticeable influence in comparison with other factors in California, where comparatively recent sedimentation has undergone intensive diastrophism. A generalized picture of the relations to depths up to 7,000 ft. are shown in the accompanying chart.



The practical uses of a knowledge of temperature gradients in oil wells are numerous and important, for the following reasons:

Reservoir content studies and space-volume relations are vitally dependent upon temperatures.

Geological correlation with structure, as well as detection of faults is sometimes possible.

Possibilities exist for detecting or observing subterranean water movement. (Based upon transient temperatures in wells.)

Mud performance and stability in drilling wells is affected by heat.

Chemical treatment of wells in cleaning out, or plugging water sands may be affected by heat.

Selection and application of cement as well as calculation of safe drilling-out time should be based on accurate temperature data.

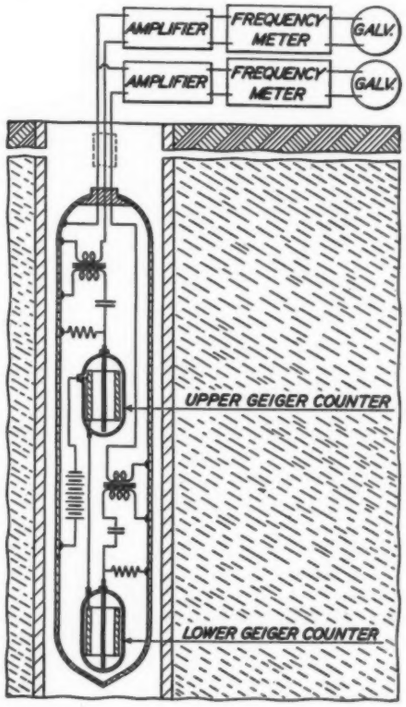
Design of tools, instruments, and materials for use in drilling or producing wells must recognize temperature conditions which may be critical in some instances.

Thermodynamic analysis of flow tube design and the use of phase-equilibria tables require detailed temperature observations.

Temperature surveys are accepted for the location of freshly placed cement outside casing and in scattered instances, have logged formations behind casing, detected water sources both in open and cased hole, and located gas or oil producing horizons in open hole.

Gamma-Ray Well-Logging—Lyon G. Howell and Alex Frosch, in GEOPHYSICS, vol 4 (1939), No. 2, pp. 106-114.

In this work on gamma-ray well-logging there were two motivating points of interest. There have been references in the literature to indicate that oil is fairly high in radioactive content, and there was some hope that oil bearing formations might be distinguishable from other formations. This is an important problem in well-logging. In the second place, the present commercial electrical well-logging practice can not be used inside cased wells due to the shielding action of the casing There are a number of old fields which were brought in before the advent of electrical logging and thus no logs of these cased wells can be obtained except through the casing. Again in present day gun perforating practice, a more accurate method of locating the gun in the oil bearing formation is needed. A possible solution is the use of a well-logging instrument capable of working inside the casing in conjunction with the gun. It is difficult to hit upon a physical quantity which can be measured through the casing in the well.



An instrument about 12 ft. long and 3½ in. in diameter, containing two Geiger counters has been developed for the purpose of detecting radioactivities of formations in bore holes. Logs can be taken at a speed of the order of 25 ft. per minute. Characteristic variations of radioactivity have been measured in both cased and open holes; in fact, all measurements are made through at least one thickness of pipe since the Geiger counters are enclosed in a steel case. Logs have been taken in both West Texas and the Gulf Coast, changes in which logs can be correlated with geology. A most interesting and surprising factor is the similarity in behavior in many instances between such widely different physical properties as those measured by electrical and radioactivity logs. No evidence of high radioactivity in oil sands has been found; but, on the contrary, oil sands like other sands have been found to possess low radioactivity.

It may be said that for obtaining logs which can be correlated with geological formations, the radioactivity method offers, for the first time, a general method for working inside the casing.

DRILLING

Directional Drilling of Several Wells from One Derrick Foundation—B. Mills, in OIL WEEKLY, vol. 93 (1939), No. 5, pp. 14-16; 18, 20.

Directional drilling has been successfully applied to several swampy and submerged areas along the Louisiana Gulf Coast. The use of this development method has effected a considerable saving in location expenditure, since from three to nine wells may be drilled from a single pier combination, or island.

The pier arrangement usually is such that the derrick can be skidded a short distance, the slight shifts in operations placing the wells from 24 to 34 ft. apart at the surface. The grouping or cluster arrangement makes possible the use of one large pier assembly for several wells. In the swampy areas, one road serves the entire group of wells, while at water locations the island for four or six wells may be constructed at a much smaller cost than for four or six separate islands or pier assemblies located several hundred feet apart.

The first well is usually completed as a straight hole; the others are slant holes which at depths below 5,000 ft. may drift horizontally 600 to 1,100 ft. (At the maximum drift of 1,100 ft. this would give approximately 20-acre spacing to six wells).

The proposition is one of economical drilling. A pier for the first well in these swampy or open water locations costs about $75,000. A pier island for drilling five additional wells costs $150,000. Thus the cost of foundations for six wells is only twice that of the cost of the first well. The slant holes have offered no particular difficulties in casing and completion, and apparently have not affected yield.

Cement for Oil Wells—Status of Testing Methods and Summary of Properties—Committee Report, presented by W. W. Robinson before AMERICAN PETROLEUM INSTITUTE, New Orleans Meeting, May, 1939.

The placement of cement in oil wells presents problems for both oil operator and cement manufacturer. Particularly in the case of deep drilling the need for special cements has resulted in the development of new test methods for evaluative purposes.

Although these tests have contributed to the solution of cementing problems, their development and application have not been coordinated. Consequently, considerable confusion exists as to acceptable methods and apparatus for carrying on such work.

This paper presents a compilation of methods for making special tests on oil-well cements, and provides specific information as to the practical interpretation and application of results.

The use of cement in oil wells differs from its normal use in making concrete in that: 1, cement for oil wells is used as a neat slurry; 2, the slurry

must be capable of being pumped for a considerable distance over a period of time; and, 3, the temperature of the slurry increases during placement. Because of these differences the standard A. S. T. M. testing methods, which were designed to evaluate portland cements suitable for concrete, do not provide the desired information concerning the suitability of cement for use under oil-well conditions.

Although some of the special testing methods have been described previously it is believed that a compilation of these methods of testing cement for use in oil wells will serve a useful purpose. An attempt has been made to present the procedures in a uniform style, and in this connection the liberty has been taken of re-arranging and paraphrasing the written procedures of various companies.

Detailed descriptions and directions, richly illustrated, are given for sampling, sieve tests, ring test, thickening-time, consistometer test, tensile strength test and foam test. Suggestions are given for interpreting the results.

NATURAL GAS

Dehydration of Natural Gas—H. M. Baker and J. W. Partridge before AMERICAN PETROLUEM INSTITUTE, Eastern District, Pittsburgh, April, 1939.

Three natural gas-dehydration plants, each using a different process, are in operation in the Charleston (W. Va.) group of the Columbia system. These three dehydrating methods employ respectively diethylene glycol, refrigerated calcium chloride and calcium chloride glycerin as the dehydrating agents.

Several dew point instruments were tested and investigated. To-date the only practical and efficient method of obtaining dew points is by the instrument developed by W. M. Deaton of the Bureau of Mines, Amarillo, Texas. This instrument is practical for field operation and apparently presents accurate results.

Three years' operation of the refrigerated calcium chloride plant definitely indicates that this type of plant is highly satisfactory as a means of removing only those hydrocarbons which would otherwise be condensed in the line. Any desired dew point depression within practical limits may be obtained with this type of plant by installing in connection with it, the necessary refrigeration capacity.

Two years' operation of the calcium chloride glycerin plant shows that this type plant is satisfactory where it is not necessary for the dew point depression to exceed 30-35 deg. F.

Indications to date are that the diethylene glycol process is suitable for obtaining dew point depressions of from 40 to 45 deg. F. It is felt that another year's operation of the diethylene glycol plant will provide sufficient data to compare this process with the calcium chloride glycerin process as to costs and ease of operation.

Three years of experience in the Charleston group of Columbia system has developed the following fundamental advantages in natural gas dehydration:

1. Greater reliability of gas service due to elimination of line freezes.
2. Increased line capacity and subsequent reduction in compressor station horsepower output.
3. Curtailment of gas losses incurred in blowing drips and syphons.
4. Curtailment of line walker personnel.

These points, together with comparatively low dehydration costs, indicate that dehydration should be an integral part of natural gas transmission systems.

Natural Gas, an Expanding Industry—Paul Ryan, in OIL AND GAS JOURNAL, vol. 37 (1939), No. 52, pp. 26-27.

The automobile business has long been considered one of the great basic industries of the United States, affording employment to many thousands and manufacturing a product which has become essential to the complex industrial civilization of this country.

Yet the average person would probably be surprised to learn that the investment in the natural gas industry is more than double the amount of capital employed in the production of automobiles. While some $1,369,631,000 has been invested in the automotive plants of this country, over $2,700,000,000 of capital is required to provide natural gas service to 7,220,000 customers.

An important factor in the maintenance of the high standard of service to which natural gas customers have become accustomed, is the tremendous amount of capital that stands back of each worker in the natural gas industry. For example, in the automobile industry, approximately $3,000 has been invested in plant and machinery for each worker employed. In the case of steel, this figure is about $7,000, while the railroads have an investment of approximately $24,000 for each employee. Yet the average worker in the natural gas industry has behind him the tremendous investment of $41,000.

In the 15-year interval from 1923 to 1937, manufactured gas has been replaced by natural or mixed natural and manufactured gas in communities with a population of nearly 19,800,000 people, and approximately 3,764,000 customers have been affected by the change. During this period natural gas has been made available to over 2,300,000 customers who had not previously been served with any gas fuel.

The relation of natural gas to the electrical industry is illustrated by the fact that if a buyer were in the market last year for 1,000,000 B. T. U.'s of energy, he could purchase them in the form of natural gas for $0.35, and in the form of electric energy for $6.82.

It is doubtless for this reason that the electric industry is to an increasing extent, turning to natural gas as an economical and dependable method of power production. In 1938 approximately 173,000,000,000 cu. ft. of natural gas were used as fuel for generating electric power. That is to say, nearly one-fifth of all the steam generated electricity of this country was produced by natural gas.

Preliminary estimates indicate that the total production of natural gas in 1938, including amounts used in the manufacture of carbon black and for field purposes, reached an all-time high of more than 2,500,000,000,000 cu. ft. or more than two percent above the previous peak established in 1937.

REFINING

Blending of Motor Fuels—W. B. Engelbrecht, Harold M. Trimble and Harold I. Hoover, before NATURAL GASOLINE ASSOCIATION AMERICA, Tulsa Meeting, May, 1939.

These authors made a study of the data of many blending experiments to see whether they could prepare charts that would indicate the characteristics of a blend of any two fuels.

The result was the preparation of a chart to determine Reid vapor pressure of blends of high and low volatility gasolines; this chart is easily constructed by plotting the Reid vapor pressure

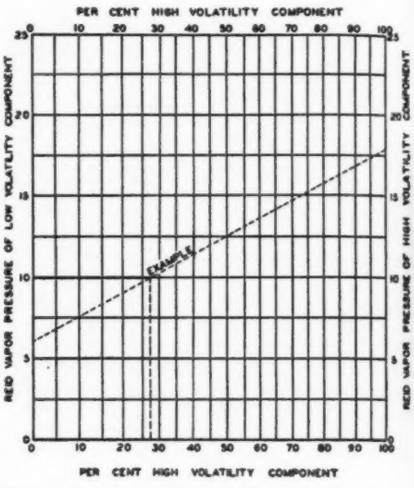

PER CENT HIGH VOLATILITY COMPONENT
0 10 20 30 40 50 60 70 80 90 100
REID VAPOR PRESSURE OF LOW VOLATILITY COMPONENT
REID VAPOR PRESSURE OF HIGH VOLATILITY COMPONENT
0 5 10 15 20 25
EXAMPLE
PER CENT HIGH VOLATILITY COMPONENT

Chart for determining Reid vapor pressure of blends of high and low volatility gasolines.

of the high and the low vapor-pressure components on the opposite vertical sides of coordinate paper against percent of high volatility component on the horizontal axis. The accompanying diagram shows how to solve the problem of blending an 18-lb. gasoline with a 6-lb. base stock to produce a 10-lb. blend. A similar chart gives percent evaporated at any given temperature; with these charts it is possible to produce blends according to desired specifications.

They also give a number of charts by which to estimate the savings of tetraethyl lead that might be made through the use of natural gasoline in raising third-grade gasoline from around 50-55 octane number to 67 octane number (L-3 method).

Carrier Distillation Process for Asphaltic Lubricants—W. Kraft and W. J. Bloomer, before WESTERN PETROLEUM REFINERS ASSOCIATION, Shreveport Regional Meeting.

Two methods are available for de-asphalting heavy residua: (1) chemical and/or solvent treating; (2) distillation, using vacuum, steam, inert gas, a carrier, or other means. The Conbrough process mixes a light, non-viscous distillate of the order of kerosene or light gas oil in varying proportions with heavy residuum and, by the partial pressure effect of mixed vapors, distills overhead the lubricating fraction, recovering asphalt as residual bottoms. The process is described and the discussion of the paper given in the article.

Multi-Layer Construction of Thick-wall Pressure Vessels—T. McLean, Jasper, before AMERICAN PETROLEUM INSTITUTE, New Orleans Meeting, May, 1939.

Multi-layer construction is a development which has grown out of the failure of small thick-wall high-pressure vessels to give the service expected of them.

The shortcomings of vessels that have been constructed in the usual manner were shown for the

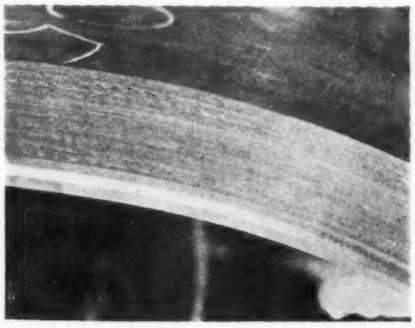
first time by tests made by the A. O. Smith Corp. of Milwaukee.

Four thick-wall pressure vessels, 12 ft. long, with an outside diameter of 33¼ in., and a total wall thickness of 3⅝ in., were built in the Smith plant several years ago and tested to destruction. In no case was the pressure value at failure more than 75 percent of what had been expected according to commonly-accepted cylinder formulas. A careful study of the test data thus gathered made it apparent that the accepted formulas were not applicable for heavy solid-wall small-

Two sections of a multi-layer vessel shown after 26 layers progressively have been wrapped and welded.

diameter vessels, i.e., vessels in which the ratio $\frac{D}{t}$ of diameter to wall thickness — was in the neighborhood of 10 or less. Examination of the available literature on the subject failed to produce any record of previous destruction tests with high-pressure vessels of these dimensions—whether welded, forged, or cast.

These facts stimulated an investigation on improved methods of construction and the multi-layer vessel is now commercially established. The multi-layer vessel is constructed of several layers



The tight fit between various layers is apparent from this close-up of a multi-layer shell.

of de-scaled steel, each progressively wrapped and tightened around the cylinder by mechanical means and then welded together at the edges. The discs inserted in the ends are to hold the inside layer in position while the first few subsequent layers are added. The thickness of each outside layer is generally less than ¼ in., whereas the inside layer may be heavier. Only the inside layer is leakproof. Each subsequent layer is perforated with small holes for venting.

After all layers have been added, the ends are machined for the welding groove. The contact between layers is so uniform that it is difficult to determine from visual inspection that the vessel is not made from solid steel plates.

With the ends machined, the sections are assembled by welding in a manner similar to the way sections of solid-wall vessels are joined.

Two vessels of multi-layer construction were built for destruction tests, and provided with reinforced openings in the cylinder and in one head. These vessels were constructed of 12 layers of steel of varying thicknesses totalling about 3.85 in. The vessels had an outside diameter of 27 in., and were about nine feet between heads. When tested to destruction, they failed at hydraulic pressures of 19,100 and 20,200 lb. per sq. in., respectively. These pressures correspond to maximum stresses of 58,000 and 62,000 lb. per sq. in., respectively. Both vessels were made of ordinary boiler-steel plates.

A number of such vessels have been constructed for service in hydrogenation at high temperatures and other exacting uses. Their advantage lies in their lower cost of construction and smaller weight for equivalent strength. Extremely important is the fact that the inner layer may be of any corrosion resistant metal.

CHEMISTRY

Chemistry and Mechanism of the Pyrolysis of Ethylene (A Way Toward the Technical Production of Butadiene)—Martin Schultze and George R. Schultze, in OEL UND KOHLE, vol. 15 (1939), No. 10, pp. 193-198; No. 11, pp. 215-220; No. 12, pp. 233-241.

The pyrolysis of ethylene was studied by two different methods: a static heating at temperatures between 673 deg. C., and 953 deg. K. and pressures between 300 mm. and 1,156 mm. Hg., and in a flowing system at temperatures of 1,050 deg. C. and 1,157 deg. K. with pressures around one atmosphere, using nitrogen as a diluent.

The pyrolytic reactions are quite different in the two systems. At lower temperatures the polymerizing reaction $C_2H_4 = C_4H_8$ chiefly predominates; at higher temperatures the primary reaction is chiefly a condensation: $C_2H_4 = C_4H_6 + H_2$. The kinetics and mechanisms of the two reactions are explained so far as the numerous secondary reactions will admit.

The chief practical result of the investigation is the indicated possibility of preparing 1,3,butadiene on a technical scale from ethylene and acetylene. The reversible reaction, $C_2H_2 + C_2H_4 = C_4H_6$ is particularly smooth. This is of importance because butadiene is the raw material for synthetic rubber.

Analysis of the Kerogen of Oil Shales—A. L. Down, in JOURNAL INSTITUTE PETROLEUM, vol. 25 (1939), No. 186, pp. 230-237.

The economic importance of oil shales and related materials depends entirely on their content of organic matter, and no substantial advance in our knowledge of their constitution can be made unless the composition of that organic matter, usually termed kerogen, can be correctly determined. Owing to the high percentage of mineral constituents present in most oil shales and their intimate association with the kerogen, the true amount of organic matter and its composition cannot be ascertained easily. Whereas the percentages of organic carbon, nitrogen, and sulphur can be estimated directly, the organic hydrogen and total mineral matter contain errors of considerable magnitude due to the unknown amount of water present in the hydrated minerals.

Previous attempts to analyze oil shales have been limited mostly to extraction by organic solvents. Ultimate analysis by combustion is impracticable because of the difficulty of first removing combined water. The author solved the problem as regards Scotch oil shales by dissolving out the inorganic matter with hydrochloric and hydrofluoric acids, by which means 99 percent of the inorganic material was removed. The deashed samples then showed the following compositions:

Mine	C	H	N	S	O	Mineral Matter
			(Percent)			
Kimeridge	66.68	6.87	1.34	8.54	13.25	3.32
Broxburn Main...	79.33	8.56	2.39	0.10	8.38	1.34
Middle Dunnet...	77.83	8.09	2.62	1.22	9.22	1.02
Pumpherston, 1..	79.13	7.56	2.27	0.60	9.32	1.12
Pumpherston, 2..	77.42	8.30	3.12	0.46	9.33	1.37

The oxygen ratio of shale oil from the lower carboniferous is markedly different from that of Jurassic age (Kimeridge).

The Role of Free Radicals in the Oxidation of N-Heptane—Robert Maess, in OEL UND KOHLE, vol. 15 (1939), No. 15 pp. 299-306; No. 16, pp. 321-326.

The question as to what causes knock in a gasoline engine has given rise to numerous investigations. From these studies there has been evolved a theory that the knocking fuel first breaks up into reaction chains which are secondary decomposition products produced by the activity of free radicals. These radicals are the first products of the decomposition. These secondary reaction chains are supposed to be quite long and undergo a vigorous reaction at temperatures where the thermal decomposition of the pure hydrocarbon is still unmeasurably small. It is this chain reaction that is supposed to cause the knock.

In this study the author made some experiments to see whether the oxidation process could be accelerated by the artificial introduction of free radicals, and thus to obtain evidence for or against the presence of a radical-chain mechanism. Azomethane and acetone were used as sources of free radicals. It was found that the thermal decomposition and also the oxidation of n-heptane are accelerated by both these substances merely under the influence of light, or by induction of thermal decomposition of the azomethane. The reaction is of the second order as regards the concentration of the azomethane and is independent of the concentration of the n-heptane. Among the reaction products are propane, propylene, butane, butylene and ammonia, from which it is concluded that the n-heptane undergoes a splitting.

The photo-oxidation of acetone and azomethane is independent of the temperature, and after a certain induction period may result in an explosion at a relatively low temperature (250 deg. C.)

ASPHALT & TAR

Rapid Determination of Soluble Bitumen in Road Carpets—L. J. Chalk, in JOURNAL INSTITUTE PETROLEUM, vol. 25 (1939), No. 185, pp. 168-177.

Few chemists engaged in the asphalt industry have not experienced the need for a simple rapid and reliable method for determining soluble bitumen in road carpets, and particularly is this the case with those employed in the laboratory supervision of road constructional works. The procedure adopted by the British Standards

Institution is often unsuitable where results are urgently required, owing to the length of time necessary for the filtration. Asphalt cements containing large amounts of Trinidad Lake Asphalt and carpets incorporating these cements are notable in this respect. The difficulty is further accentuated where the size of the coarse aggregate necessitates the use of a large sample.

A detailed account is given of two rapid but reliable methods employed by the author for the determination of soluble bitumen in road carpets.

The first consists of a hot extraction process in which a tall metal beaker replaces the usual Soxhlet form of apparatus. The sample is placed in a wire gauze basket suspended inside the beaker and loss of solvent is prevented by closing the top of the beaker with a condenser made from lead compo' tubing. The bitumen is determined by difference.

In the other method, a known volume of solvent is added to the sample and the mixture agitated until the bitumen has completely dissolved. An aliquot portion of the solution is then evaporated to dryness and the bitumen determined by direct weighing.

The necessary precautions and manipulative technique are described in detail in each case. Both methods are extremely simple in character but give results in good agreement with the B. S. I. method.

Testing Asphalt Mixtures—Anon., ROAD AND ROAD CONSTRUCTION (London), Feb., 1939, p. 44.

For the determination of the percentage of soluble bitumen in various asphalt plant mixtures, the Engineers' Department of Sydney, Australia, uses a Photo-bilometer. This apparatus has a rectifier type photo-cell and a low-voltage high amperage exciter lamp, the photo cell having a peak sensitivity to a wave length corresponding to infrared. To 10 gr. of the sample 250 cc. of trichlorethylene is added, the bitumen being thus dissolved in about half an hour. The solution is filtered into a special trough pushed into the apparatus. This automatically switches on the current and the density and color value is read on a microammeter, on the top of the instrument, which by reference to a standard calibration curve, can be translated into the value of the soluble bitumen content.

(Note: An apparatus based on the same general principles, developed by Wisconsin State Highway Engineers, is described in ENGINEERING NEWS RECORD, February 16, 1939, page (231) 73 —Ed.)

USE

Torsion-Cone Consistometer—M. H. Arveson and L. C. Brunstrum, in OIL AND GAS JOURNAL vol. 37 (1939), No. 46, pp. 83-84.

There is a wide range in the consistency and structure of lubricating greases, and numerous instruments have been invented for measuring these properties, mostly using unrelated principles of measurement. The commonest is the A. S. T. M. cone penetrometer (D217-33T) which is used on the heavier lubricants. But this instrument has the disadvantage of a range which is too narrow to include the softer greases and it gives inaccurate results on the extremely heavy ones.

To provide a single instrument that would avoid the disadvantages of the A. S. T. M. instrument the authors decided to utilize the principle of measuring the force required to push a disc through the grease, somewhat analogously to the old-fashioned finger test for consistency. The procedure is as follows: a sample is placed in a cylindrical cup and after adjusting its temperature in a thermostat the cup is placed on a platform which is moved vertically upward by a mechanism driven at a constant rate of speed (18 mm. per minute) by a motor. Just above the grease cup is a disc having an area of one square centimeter attached to the lower end of a rod which transmits the upward thrust due to the resistance of the grease to a balance arm. The deflection of this balance arm is noted as it becomes constant when the center of the cup is approached.

Before putting to service the instrument is calibrated by known weights. Since the instrument was first used six years ago the calibration values have not altered, and it has given reproducible results on a wide variety of greases. The values obtained are approximately a linear function of the soap contents.

Aviation Fuels—Present and Future Developments—S. D. Heron and Harold A. Beatty, before AMERICAN PETROLEUM INSTITUTE, New Orleans Meeting, May, 1939.

The development and standardization of aviation fuels in the United States has been exceedingly rapid, and the present status reflects great credit on all concerned with the development. However, some phases of standardization of specifications and test methods urgently require action, and extension of research investigation along certain lines is much needed.

Formerly the Army and the Navy had different specifications for aviation fuels. These have now been combined, and although details of these specifications may not be published, it is permissible to state that six grades were adopted. These grades include four octane-number requirements, three distillation requirements, and specify the Army method of knock test throughout. Three of the grades do not permit the addition of lead, and the remaining three grades have different maximum permissible lead concentrations but do not specify minimum lead concentrations. All six grades permit higher 90 percent points, and three grades permit higher 50 percent points, than allowed in the commercial specifications. Whereas the Army and Navy distillation requirements will not permit the use of Army and Navy grades in commercial service, the commercial-distillation requirements do permit fuels meeting them to be supplied for Army and Navy use.

There still remain divergencies between military and commercial specifications, removal of which would be of great value in times of national emergency. The essential differences between the government and commercial specifications, apart from octane-number requirements, are method of knock test, A. S. T. M. 90 percent point, maximum permissible lead content, and minimum permissible lead content.

It would appear that the economic interests of the petroleum industry would be served best by a single set of specifications, even though this might result in a slight increase of difficulty of manufacture in some cases. Any slight increase in cost of manufacture apparently would be offset by economies in storage and distribution. The military services and the large commercial operators are using almost entirely identical engine equipment. It is reasonable to hope that it will be possible, by minor adjustments, to obtain agreement as to the majority of requirements by the Army and Navy on one hand and the engine manufacturers and air-line operators on the other.

The present situation in regard to knock testing is far from satisfactory; existing methods are not sensitive above 92 octane number, but hope is placed in new methods, which will eventually involve supercharging, now being worked out by the C. F. R. Aviation Fuels Division (A. F. D.). It seems that an entirely new anti-knock scale must be worked out, especially for fuels near or above 100 octane.

Laboratory Method for Indicating Road Performance of Motor Fuels—Herschel G. Smith, before AMERICAN PETROLEUM INSTITUTE, New Orleans Meeting, May, 1939.

It is admitted generally that the actual performance of an automotive engine affords the most definite picture of the quality of a fuel for the unit in question. The standard laboratory tests are necessary for control of properties of a motor fuel, but usually the results may be considered merely as approximate indications of the characteristics. The industry long has recognized the need for a reliable and economical combination of a laboratory and performance test.

After several years' study of the subject, the author (working with the Gulf Oil Corp.) decided that perhaps the best substitute for tedious and expensive road tests would be a laboratory test procedure that would include the time element for loading the engine and picking up speed, and that it should be feasible to operate with inertia load such as would be afforded by a flywheel of suitable weight and design, either with or without a complementary brake or dynamometer load. By arranging for the absorption of power by the inertia of the flywheel a time interval of about 90 seconds is afforded for observations of conditions similar to those encountered by a car operator in casually throwing the throttle wide open after a stop.

On this basis a procedure to be known as the acceleration inertia-load test (A. I. L.) has been devised. The principal feature of the equipment is a 2,550-lb. alloy-steel flywheel having inertia of the same order as that of an automobile of average weight, in combination with a brake for deceleration. The set-up is so arranged that one make of engine after another can be attached to the flywheel; a more elaborate equipment would be a permanent installation with a flywheel for each of three engines of different makes—a Ford, a Chevrolet and a Plymouth—and suitable accessories and instruments.

With this outfit gasolines are regularly tested in comparison with secondary reference fuels. The sample data of tests on 246 gasolines tested on all three engines indicate that results can be reproduced within plus or minus one octane number or less. The entire cost of the outfit including the three engines and the instruments, was approximately $3,100, or about one and one-third times the cost of one standard C. F. R. unit.

SUBSTITUTES

Treatment of Shale Oil by Hydrogenation—M. Pier, in JOURNAL INSTITUTION PETROLEUM TECHNOLOGISTS, vol. 24 (1938), No. 182, pp. 692-705.

The experiments described indicate that it is possible by catalytic hydrogeneration under pressure to produce marketable products of high purity with exceptionally high yield from shale oil and from the oils obtained by low-temperature carbonization of shale.

Paraffin wax, lubricating oil and Diesel oil can

be obtained from Scottish and similar paraffinic shale oils with almost 100 percent yield by weight. The properties of the lubricating oils correspond to those of Pennsylvanian machine oil. Paraffinic and asphaltic shale oils, such as Estonian shale oil, can be converted with 85 percent yield by weight into Diesel oil with cetene number 60-75 together with a small quantity of petrol.

All types of shale oil can be converted into motor petrols with approximately 80 percent yield by weight—i.e. more than 100 vol.-percent yield, which have octane numbers between 65 and 67 and possess a high lead sensitivity. Petrols of higher knock-rating may be produced by reduction of the end-point, and in particular by means of aromatization.

RESERVES

New High Level of Crude Oil Reserves in the United States—L. G. E. Bignell, in OIL AND GAS JOURNAL, vol. 37 (1939), pp. 20-23.

Crude oil reserves in the United States on January 1st totaled 14,351,520,297 bbl., the largest proven underground supply in the history of the industry.

The reserves found in 18 states represent an increase of 862,062,353 bbl. over the total reported a year ago. This gain is accounted for by revisions of estimates reported for old fields discovered previous to 1938 and by entirely new discoveries in 1938.

A year ago, reserves of 13,489,457,944 bbl. were reported. The reserve estimates for existing fields are constantly changing, due to new developments; and in this year's report the figure for January 1st, 1938, is revised upward to 13,975,816,944 bbl. The addition of 486,359,000 bbl. is largely accounted for by increased reserves credited to fields in Texas.

Considering 1938 alone, the year brought new discoveries which at the start of this year represented new oil reserves of 1,589,760,353 bbl. This exceeded by 375,703,353 bbl. the preliminary estimated 1938 production of the United States totaling 1,214,057,000 bbl.

These data, summarized, mean that new developments in old fields added 486,359,000 bbl. to proven reserves, while the reserves of 1938 fields exceeded production by 375,703,353 bbl. making a total gain of 962,062,353 bbl. for the year.

Roumania's Oil Reserves—G. Macovei, in ANNALES MINES ROUMANIE, vol. 22 (1939), No. 2, pp. 57-58.

The oilfields of Roumania are apparently on the way to exhaustion. From 8,700,000 tons in 1936 production in 1937 dropped to 7,150,000 and in 1938 to 6,500,000 tons. This decline has naturally caused much uneasiness as regards the future of the country's oil industry, particularly in government circles, where the prospect of a decrease in revenue is distinctly unwelcome

The author points out that the difference in production between 1936 and 1938 is a consequence of irrational exploitation. The oilfields have been produced at an abnormal rate. Under prudent operation the rate of production should not have exceeded 5,000,000 tons a year, and under this condition time would be afforded for prospecting and the development of new fields; the ultimate production would certainly be larger under conservative methods. As it now is, exhaustion of the two principal districts, Prahova and Dambovita seems to be accelerating with no new reserves in actual sight.

As regards possible untouched if more or less unknown oil resources, there are at least 500,000 acres of prospective oil country in various regions, notably west of the Carpathian Mountains, where there are numerous favorable structures. Of these half million acres of possible oil fields, at least 50,000 should produce in commercial quantities. What the Roumanian oil industry chiefly needs is less haste and waste in exploiting known fields and more courage in opening new fields so that the country's wealth of oil may be developed along conservative lines.

Kansas Proven Natural Gas Reserves—Dal Dalrymple, in OIL AND GAS JOURNAL, vol. 37 (1939), No. 50, pp. 28-29; 36.

Proven reserves of natural gas in the Hugoton field of Kansas are among the larger reserves of the nation. With an assumed area of 1,380,000 acres, a 45-ft. pay thickness, a 20 percent porosity and an abandonment pressure of 40 lb.—low owing to lack of formation water—there would be a reserve of 13,736,375,000,000 cu. ft., which would be 9,953,895 cu. ft. an acre. Other estimates have been made by various geologists and engineers, mostly too conservative in view of frequent extensions of the productive area. These estimates range from 8,030,560,000,000 cu. ft. to 15,203,765,392,640 cu. ft. The later figure includes Texas County, Oklahoma, and was made in 1931. Whatever the true figure, Hugoton rates among gas fields pretty much as East Texas ranks among oil pools.

Discounting the least optimistic of these estimates 50 percent and assuming a gas withdrawal of 100,000,000 cu. ft. daily, the Hugoton field would still supply such a market for 110 years.

Other Kansas gas areas include the new Downs pool near Wichita, Sedgwick County producing from Stalnaker sand about 2,195 to 2,220 ft.; the Sterling, Orth and Stumps areas in Rice County; Pawnee Rock pool, Pawnee County; the new Ford County pool; Wellington and other areas in Sumner County, and the numerous pools of eastern and south-eastern Kansas.

Some 50 of the 105 Kansas counties have proven to be productive of gas in commercial quantities. The peak year for gas production was in 1908, when 80,740,000,000 cu. ft. were produced. Production dropped from that peak to a low of 15,717,000,000 cu. ft. in 1921. Since 1930 production has been increasing and in 1938 was around 75,000,000,000 cu. ft.

Today, Kansas is in the strongest position considering reserves it has ever occupied. Undoubtedly, additional gas reserves will be found and additional counties added to the list of gas producers as exploration continues. However, commercial development of the field is retarded by the lack of pipeline outlets the construction of which is opposed by coal mining interests that are fearful of losing some of their own market.

California Oil Reserves, 1938—Harold W. Hoots, before AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Oklahoma City Meeting, March 1939.

Developments in California during 1938 added an estimated 253,000,000 bbl. to the state's known oil reserve, an amount which exceeds by 33,000,000 bbl. the year's demand for California crude. The net quantity of estimated reserves, is, therefore, slightly higher than a year ago. Discovery of five new fields and new producing zones in four fields discovered in former years contributed an estimated 143,000,000 bbl., while development of earlier discoveries, principally those of 1936 and 1937, accounted for the remaining 110,000,000 bbl.

Known oil reserves in California at the close of 1938 are estimated at 3,147,000,000 bbl. This quantity, although materially less than the 3,869,000,000 estimated for 1928, is 87,000,000 bbl. greater than the estimated for 1936.

Known reserves declined from 1928 to 1936 principally because exploration during the intervening seven years was discouraged by the excessive flush production of Kettleman Hills, Elwood, and Santa Fe Springs and, later, by more general adverse economic conditions. The return of more favorable conditions generally and within the industry, together with a realization that additional known reserves were needed, led to an increase in exploration and the distinct improvement in the discovery rate apparent for the last three years.

The present improved rate of discovery, although keeping pace with consumption, is not satisfactorily replenishing the decreased known reserve supply. Further improvement is desirable. The rate of discovery, however, appears to be directly related to the quantity of exploratory geology and drilling, and any increase in these activities, or continuations of their present rates, is now discouraged by the present excessive capacity to produce known reserves.

ECONOMICS

Economics of Gravel Packing in California—Wm. A. Clark, before AMERICAN PETROLEUM INSTITUTE, Pacific Coast District, Los Angeles, April, 1939.

This paper is a progress report covering the performance of gravel packed wells in the San Joaquin Valley and Los Angeles Basin in comparison with conventional wells in the same districts. At the present time the average monthly production per well favors those that are gravel packed by 41 percent.

From the cost data here assembled it appears that gravel packing will pay out in about two years in the Los Angeles district and in a somewhat longer time in the San Joaquin district. However, intangible benefits such as preservation of the liners and perhaps lack of silting-up of the well bore, are expected to count effectively on the profit side. There are several reasons to explain the greater production of the gravel-packed wells.

The gravel-packed wells may pump for long periods before pulling, while the conventional wells during that time are gradually filling with sand (or the sand is wearing out the pump), reducing output for several days or weeks. When the latter well is pulled, additional downtime occurs, further reducing the month's total production from the conventional well.

Better pump efficiencies on account of inserting the pump deep within the liner in the gravel-packed wells, a practice that is hazardous on account of sanding-up in conventional wells.

Possible improved productive efficiencies from the zone due to the large diameter hole in the gravel-packed wells.

In the west side area of the San Joaquin Valley, an expanding gas cap and lowering fluid level has made pumping a difficult matter due to gas lock and heaving in conventional wells when the fluid level has approached the top of the zone. In the graveled wells very little trouble is encountered from the causes mentioned; the gravel prevents heaving and appears to act in part as a gas separator.

Russian Oil Survey—Part IV

Fourth of a Series Dealing with the Soviet Petroleum Industry in All Its Phases. Baku, Grozni and Maikop Have Been Dealt with in Previous Issues, While This Article Surveys the Daghestan, Crimea, Kuban-Black Sea, and Georgia Oilfields. Next Month Mr. Wegrin Discusses Emba.

APART from the major oil developments at Baku, Grozni and Maikop, in the Caucasus, the regions of Daghestan, Crimea, Kuban-Black Sea and Georgia are progressing steadily, if somewhat slowly. Production activities first were carried out in these districts at the turn of the century, but it has been the improved methods of geological exploration and better drilling technique that have rendered them significant. Even so, their importance lies in the future rather than in the present, for they represent a somewhat small percentage of the nation's total crude oil output and, although they hold promise, it will undoubtedly be some time before they are developed adequately.

Sovfoto

A wild-cat well at Atly-Buiuk, on the Daghestan coast.

GEORGIA

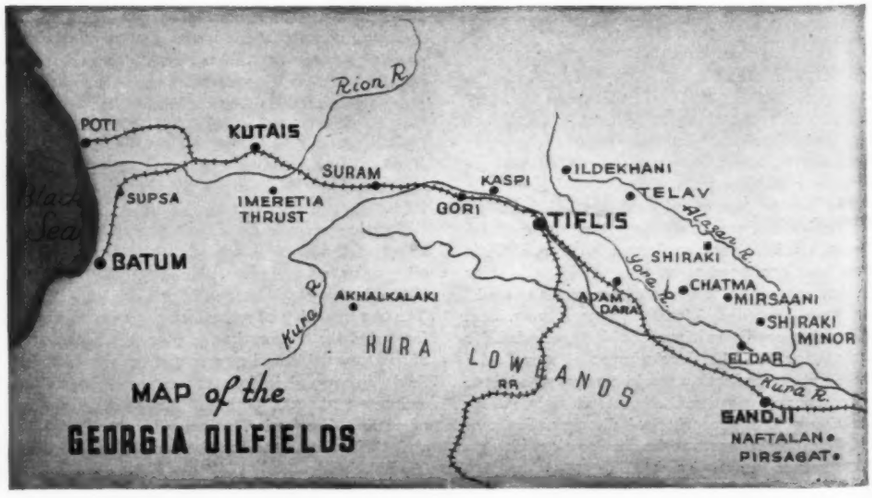
The Georgian oilfields—principally Shiraki, but excluding Pirsagat and Naftalan—produce altogether about 335,000 tons of crude yearly from about 200 wells. The Georgian province consists mainly of mountains and plateaus and is bounded on the west by the Black Sea, on the north by the Caucasus Mts. which are a part of it, on the south and southeast by Turkey and Azerbiadzan.

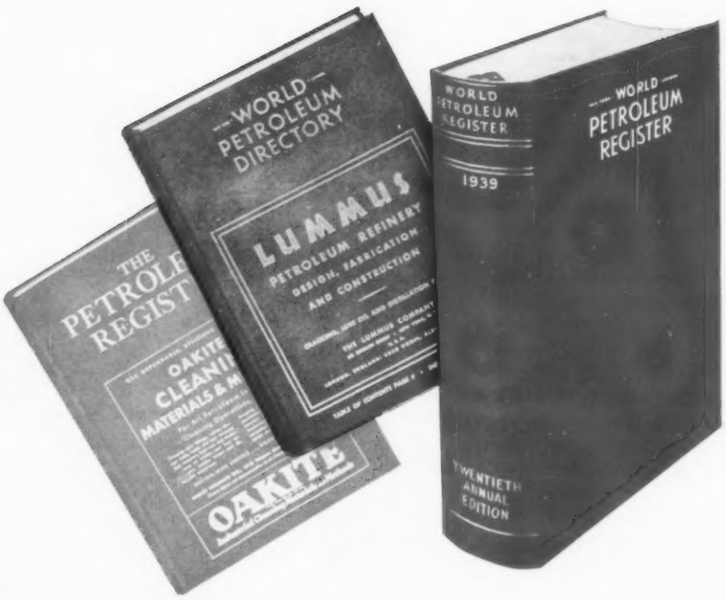
Oil was known to exist in Georgia early in the century and a number of attempts to exploit it were made, with only minor results due to the inadequate geological studies and poor drilling technique of the time. Riabinin, a well-known Russian geologist, asserted that the geological indications were unfavorable for accumulation of appreciable oil deposits. However, small quantities of oil have been produced for a number of years and since the management at Baku took over these properties the Shiraki and Mirsaani fields, with the other zones at Guria, have increased in output to about 335,000 tons annually. Shiraki and Mirsaani wells flow 10 to 15 tons daily average between 1,020 and 1,810 ft., yielding a crude with 16 percent gasoline content. More prolific horizons lie between 4,930 and 8,220 ft. and also at 9,870 ft., in the Sarmat.

Exploratory drilling has been speeded up and drilling to fairly deep levels has been undertaken at Shiraki Minor, Gori (in Kahetia); Telav and Ildekhani.

The Chatma field, about 50 mi. from Tiflis and 300 mi. from Baku along the Baku-Tiflis railroad, produces minor quantities of heavy oil. There are a number of oliferous mud volcanos similar to those at Guria, where the formations are more complicated. The Abhasia oil lands cannot be developed until the transportation problem has been solved.

Interesting petroliferous districts have been found adjacent to Azerbaidzan, along the Kura lowlands. Chief among these are the Pirsagat properties, where a number of prolific producers where obtained—Pirsagat has been incorporated into the Baku oilfield group. Another promising region near Baku is Naftalan, long exploited for a naturally-





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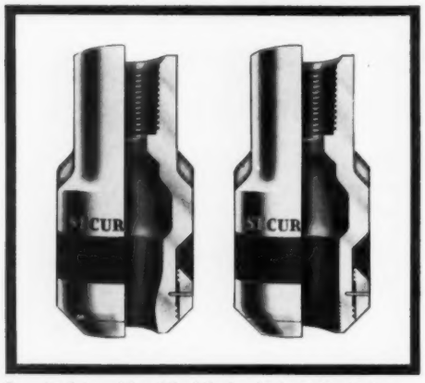

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refined oil with medicinal properties. Naftalan is between Kirovabad and Gandji and may prove to contain more prospective oil lands.

Because of their proximity to Baku the Georgian oilfields are to be developed as rapidly as possible to offset any decline of output which may occur in Azerbaidzan.

DAGHESTAN

The Daghestan province is in the north Caucasus, bounded by the Caucasian Mts. in the south, Grozni in the west, and the Caspian Sea in the east. Daghestan contains a number of small oilfields and the known petroliferous area is along the Caspian coastline between Derbent and Makhatch Kala. The territory consists mostly of sandy steppes with but few roads and communication facilities. As rainfall in Daghestan is more frequent than on the Apsheron peninsula, which it borders, the vegetation is richer along the watersheds, but the dampness and heat make it unpleasant.

Some 30 years ago an Anglo-Russian group attempted to develop the Kaya Kent district and small quantities of oil were produced. Attempts were also made to develop oil lands at other points near Derbent and at Makhatch Kala. Today the areas under exploitation between these two points are Achisu, Izberbash, Kaya Kent, Berekei and Duzlak.

The better-known regions of Daghestan are divided into two groups. One is mainly of Mediterranean formation, consisting of spanidotell sands and Chockrak spiral layers such as are found at Achisu, Kaya Kent and Izberbash. The structures are rather complex and individual sites on a single structure (i.e., Brakhi anticlinal fold) differ from each other in characteristics. Therefore development is proceeding independently in each of these three fields. The second group consists of Giliar, Adshinsur, Koch Mensil, Daghestan Fires, Duzlak, Berekei, Gubden and other regions. These prospective fields apparently belong to the Maikop series and

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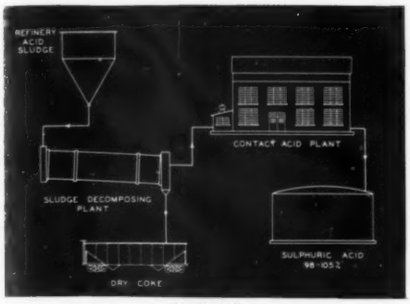

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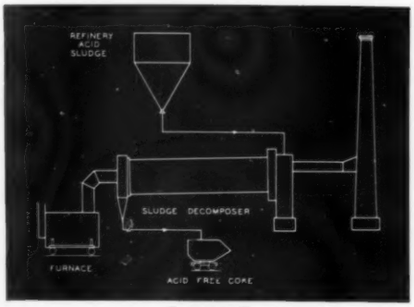

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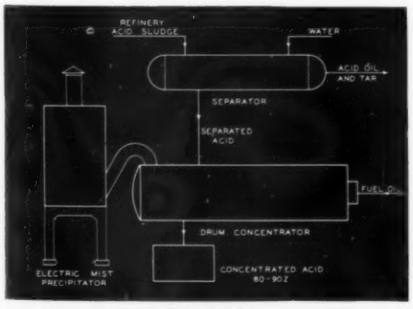

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are being prospected for gas, although oil saturation of the sands was noted in several of the wells drilled at Berekei and Duzlak. The Maikop formations at Uitash and other parts of the 30 mi. Narat Tubinsk strip also vary considerably.

The most important of the developments is Izberbash, about 40 mi. from Makhatch Kala and 35 mi. from Derbent, where there are 70 or 80 wells. The first deep wells were sunk in 1932 and when a large producer came-in during 1936 interest of the geologists and producers was heightened. Subsequent drilling failed to bring in such large producers and it is now evident that the main oil bearing horizon is at a deeper level and probably lies further out under the Caspian Sea. The producing horizon lies in the Chockrak between 5,350 and 5,440 ft. Porosity of the sands in the Chokrak varies from 15 to 25 percent, although there are a few with a porosity as high as 32 percent.

The main structures are two arch elevations formed by overthrusts of the Daghestan anticlinal fold and the northeast part, which shows a dip of 10 to 15 deg., is overthrust on the southwest while the southwest wing dips at about 85 deg. some 1,480 ft. from the axis. The maximum elevation of the overthrust arch is likely to be under the sea and not inland. The elevation is well conserved under the thrust and may prove prolific in both directions.

The Izberbash crude is of high grade exceeding that of Grozni, and yields 59 percent of light products. Planned output for 1938 had been set at 1,000,000 tons, but at the end of the year only about 75,000 tons had been produced. A few dry holes have been drilled, but the greatest problem lies with the rapid decline in yield of even the largest producers.

Kaya Kent and Achisu have between them perhaps two-score wells—as these smaller fields of Daghestan are still comparatively unimportant in Soviet oil economy detailed figures as to number of producers, etc., are not recorded.

Kaya Kent is a development similar to Izberbash. Many difficulties have been encountered with cave-in at wells, while it has taken considerable time to reach the productive horizons due to their depth. It is probable that development of Kaya Kent also will progress more rapidly when drilling is undertaken under the sea-bottom.

The Achisu development is about 25 mi. from Makhatch Kala. In this region the surface outcrops also belong to the arch of the fold, represented in compact Chockrak clays which exude drops of dark brown oil. The territory is about 250 hectares and the crude contains up to 30 percent of light products. Initially the wells gave from five to 12 tons of crude daily, and with deeper drilling the daily average increased.

Berekei is about 15 mi. from Derbent and was originally tested in 1902 by a producer brought-in for Nobel Bros.—but the area is still largely undeveloped and has a mere two dozen wells. The ground tests showed clays, oil shales, hard and dark sands, sandstone, marls and oil-bearing calcerous sands, but

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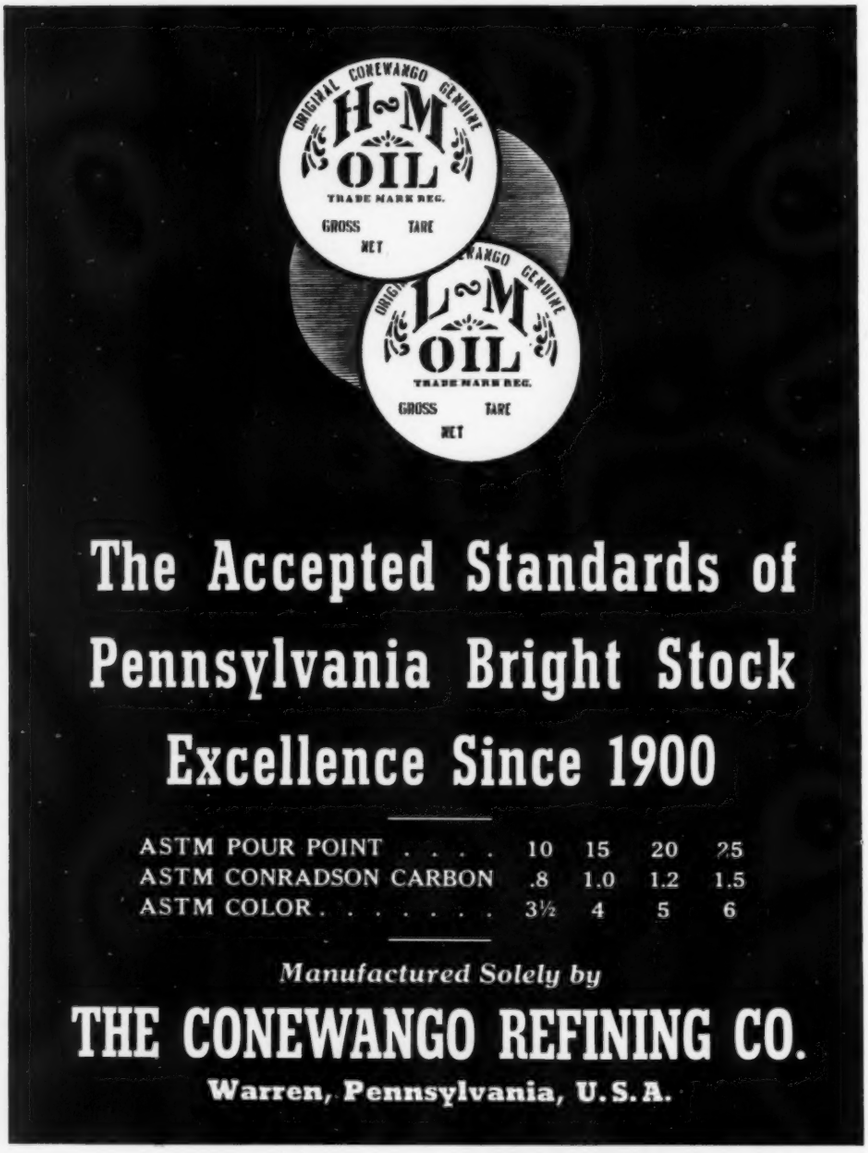

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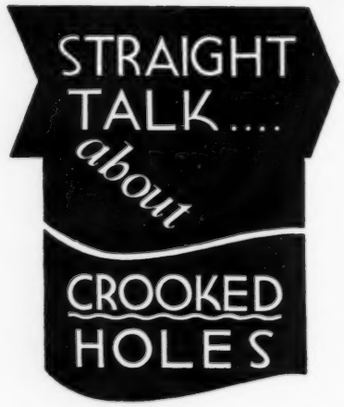

most of the oil came from the dark calcerous clay broken up by sand strings. The gas wells have a tendency to sand-up frequently and are still a problem which must be overcome.

Daghestan is more advantageously situated than Grozni in relation to the Caspian Sea. According to Soviet geologists the fields will be the major producers of the future and may replace Grozni, where the new extension has failed to replace the exhausted horizons. Daghestan lacks adequate transportation facilities for rapid expansion of producing operations but this is to be provided for by 1942 under the Third Piatiletka.

CRIMEA

The Crimea fields are purely a gas development and insignificant progress has been made in developing crude production. An appreciable amount of geological prospecting and geophysical surveys are being carried on.

KUBAN-BLACK SEA

Kubcherneft is the main producing area of the Kuban province, bordering the Black Sea; the oil lands begin west of Maikop at Kutaiski and extend to the Kertch peninsula. Some 510,000 tons were produced between 1821 and 1922 and since nationalization by the Soviets the fields have increased this output from 12,000 to about 20,000 tons per annum. This output is probably included with the Maikop production, as no separate figures are published.

Since 1935 the Soviet geologists have affirmed their opinion that the tectonics of Kubcherneft are analogous to those of Maikop and that the area is worthy of more rapid development. A few wells, with yields of 20 to 50 tons daily, were drilled at Kesslerovo, near Goriatchi Kliutch.

Exploratory drilling is being carried out in numerous districts, including Kalushski, Ilski and Krimski. Between Kalushski and Ilski wells have come-in with as much as 160 tons daily. Kuban is conveniently adjacent to the Black Sea, facilitating future export, but it is rather roadless and inaccessible with the result that supplies may not be obtained readily. Kubcherneft has bright prospects because of the apparent abundance of high-grade crude and gas.

J. WEGRIN.